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ABSTRACT

In order to study effectiveness of low-frequency amplification and filtered-speech testing for preschool deaf children, an experimental design permitting the teacher to speak simultaneously through two different amplifying systems, a low-frequency auditory training unit (Suvag I) and a conventional auditory training unit (Warren T-2), was used with 30 children. All teachers utilized the Verbo-tonal Method for habilitating the children, who were assigned to one of the two amplifying systems. Speech samples were tape-recorded at 4-month intervals, judged, and analyzed statistically. Significant improvement over testing times for both groups was found, although the Suvag group demonstrated a greater rate of improvement than the Warren group. The condition of visual and auditory clues with amplification was reported to be the best experimental condition for most children. Significant differences between the groups in terms of vocalization was found, with the Suvag group vocalizing more times per minute than the Warren group. Significant correlation was also reported between rating value and hearing level. Electrical and acoustic responses of the Suvag I unit indicated that the unit passed more low-frequency energy than the Warren unit. Reporting of related research concluded the interim report. (Author/CB)

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INTERIM REPORT
Project No. 522113
Grant No. OEG-0-9-522113-3339 (032)

The Effectiveness of Low-Frequency Amplification and Filtered-Speech Testing for Preschool Deaf Children

Carl W. Asp, Ph.D.
Principal Investigator
The University of Tennessee
Knoxville, Tennessee

March, 1972

U.S. DEPARTMENT OF
HEALTH, EDUCATION AND WELFARE
Office of Education
Bureau of Education for the Handicapped

THE UNIVERSITY OF TENNESSEE
Knoxville, Tennessee

BUREAU OF EDUCATION FOR THE HANDICAPPED

DIVISION OF RESEARCH

PROJECT NUMBER: 52-2113 Interim Report

TITLE: The Effectiveness of Low-Frequency Amplification and Filtered-Speech Testing for Preschool Deaf Children

INVESTIGATOR: Carl W. Asp

INSTITUTION: University of Tennessee

DATE OF REPORT: March 1972

BUDGET CATEGORY: Research Project

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REVIEW PROCEDURE: Field Review

RECOMMENDATION: Approval and Submission to ERIC

CERTIFICATION: M. Stephen Lilly 7/17/72
Project Officer Date

7/19/72
Branch Chief Date

7/19/72
Division Director Date

SUMMARY OF REVIEWS

This Interim Report summarized the findings of the University of Tennessee project on the effectiveness of low-frequency amplification and filtered-speech testing for preschool deaf children to date, and presents complete data from the first year of the project.

The report was reviewed by one in-house and three outside reviewers, and received two approvals, one provisional approval, and one disapproval.

Two reviewers felt that the report was of good quality, and should be approved and submitted to ERIC as is. One reviewer felt that the report should not be released until the final data have been analyzed and reported. On the other hand, this same reviewer stated that "even though I question some of the research design and raise some question about the application of the data, this is work which should be reported to the professional field. " It is felt that this statement, along with the fact that it is clearly stated in the abstract that this is an interim report, and that no conclusions should be drawn, makes publishing interim findings an acceptable practice.

The fourth reviewer, who disapproved the report, felt that the project was not of sufficient quality to justify reporting the results. The conclusion of this reviewer was contraindicated, however, in the other three reviews.

While three reviewers were generally positive with regard to making results of the project available all reviewers made substantive comments in critique of the project. These ranged from comments on reporting procedures to suggestions on data analysis, and will be of substantial assistance to the principal investigator in analyzing data and preparing the final report. It is proposed that the Interim Report be approved as submitted and put into ERIC, as a means of communicating the results of the project thus far. It is further recommended that the substantive reviews be passed on to the principal investigator so that he can make use of the ideas presented in the remainder of the project. It is felt that this course of action is preferable to requiring a rewrite of the Interim Report, which would be wasteful of time and effort at this point in the project.

August 23, 1972

Dr. Carl W. Asp
Dept. of Audiology and Speech Pathology
The University of Tennessee
Knoxville, Tennessee 37916

Dear Dr. Asp:

It is a pleasure to inform you that your interim report on your project "The Effectiveness of Low-Frequency Amplification and Filtered-Speech Testing for Preschool Deaf Children, No. OEG-0-9-522113-3339 (032) submitted to the Division of Research, has been accepted, fulfilling your responsibilities under this grant.

Since we keep only an official file copy of the interim report in this office, please do not refer anyone wanting a copy to us. A copy may be obtained on an interlibrary loan basis from any of the depository libraries of the Library of Congress. A microfilm or a photocopy of the report may be purchased from the Photo Duplicating Service of the Library of Congress. Also, a microfilm or hard copy may be obtained through the ERIC Document Service. The address is: P.O. Drawer "0", Bethesda, Maryland 20014.

We appreciate your interest in the handicapped children and youth program and hope it will continue.

Sincerely yours,

Max W. Mueller
Acting Director
Division of Research
Bureau of Education for the
Handicapped

MWMueller/lms 8/23/72

ED 065977

Interim Report

Project No 522113
Grant No OEG-0-9-522113-3339 (032)

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The Effectiveness of Low-Frequency Amplification and Filtered-Speech Testing for Preschool Deaf Children

Carl W Asp, Ph D

The University of Tennessee
Knoxville, Tennessee

March 1972

The research reported herein was performed pursuant to OEG-0-9-522113-3339 (032) with the Bureau of Education for the Handicapped, U S Office of Education, Department of Health, Education, and Welfare. Contractors undertaking such projects under government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official position of the Bureau of Education for the Handicapped.

Department of Health, Education, and Welfare

U S Office of Education
Bureau of Education for the Handicapped

PREFACE

This written Interim Report reflects the contributions of many persons Some of these contributions have been indirect, for example, working with the children or obtaining basic measurements; other contributions have been more direct, like writing certain portions of this report. Regardless of the type of contribution, all are extremely important in terms of allowing this project to progress to a stage where the report was possible To give credit to all those involved is a difficult, if not impossible, task, but is a task that the writer would like to undertake. If any person is not given proper credit, it is through oversight of the writer and he alone is responsbile for it. As a result, the writer would like to list those people who have been involved in this project, although not all of them were formally employed

For clinical aspects, the teachers would include the following: Elsie French, John Berry, Patricia Parlato, Betty Brady, Julie McCallie, Cathy Berry, Judy Butler, Astrid Shell, Mary Peterson, and Janis Shirley. Our audiologists include: Dianne Vertes, Jane Madell, and Jack Ferrell. Our clinical materials person is Virginia Hochnedel who also assembled the audiograms for this report. We have been fortunate to have two supervisors from the School of Social Work, Linda Stiles and Jane Guy. These supervisors and their graduate students have been responsible for obtaining transportation for the preschool children and counseling the parents

The research assistants include: Andy Stewart, Tom Rothaar, Gary Lawson, Fred Miller, and Carol Browne Carol is also responsible for drawing the graphs for this report and assisting with some of the typing. Our electronic engineer and technicians include: Jim Keller, Philip Williams, Carl Sellers, and numerous work-study students over the past two and one-half years.

Our secretarial personnel include the following: Norma Myers, Susan Lee, and Janet Keck. These secretaries are extremely important for the communication on the project and typing of reports. Norma has been responsible for coordinating the typing for this report.

For all of these persons indicated above and those that have not been mentioned, the writer extends his deepest appreciation for the efforts of each person. The writer is proud that he has been associ-ated with this group

Finally, the writer would like to acknowledge his family: my wife, Criss; my son, Bill; and my daughter, Kathy. During the past two and one-half years, they have shared the burden of my long working hours which included evenings and weekends It has been a strain and a sacrifice for them, and I am hopeful that this sacrifice has not been in vain

It is hoped that this Interim Report serves as identifying a format and direction for the Final Report of this project. Thank you

ABSTRACT

The experimental design permitted a teacher to speak simultaneously through two different amplifying systems, a low-frequency auditory training unit (Suvag I) and a conventional auditory training unit (Warren T-2). Each unit could independently excite five headsets and five bone vibrators Mini Suvag hearing aids were assigned to children on the Suvag I unit and Zenith Vocalizer II aids were assigned to children on the Warren unit. Preschool deaf children were "matched" according to hearing levels and other available information, and then assigned to either unit. All teachers utilized the Verbo-tonal Method for habilitating the children

Speech samples (27-word lists) were tape-recorded at 4-month intervals. The teacher presented the oral stimulus or word, and the child responded by attempting to imitate the stimulus The 27 words were presented under four conditions: (1) auditory clues without amplification, (2) visual and auditory clues without amplification, (3) auditory clues with amplification, and (4) visual and auditory clues with amplification

These samples were judged on a 9-point scale and then analyzed statistically The between-group F-ratio was not significant when the earliest and latest testing times were analyzed simultaneously There was a significant improvement over the testing times for both groups The Suvag group demonstrated a greater rate of improvement than the Warren group Individual children varied in rate of improvement The condition of visual and auditory clues with amplification was the best experimental condition for most children. Most children improved in the unaided test condition (no amplification)

There was a significant difference between the groups with respect to rate of vocalization The Suvag group vocalized more times per minute than the Warren group Both groups increased in rate over the testing times. The mean duration of vocalization for the two groups was not statistically significant, but the Suvag group had a longer mean duration than the Warren group Both groups decreased in mean duration over the testing times The shorter durations were closer to the speech patterns of normal-hearing children

There was a significant correlation between 1-9 rating value and hearing level There was a noticeable correlation between the following: (1) 1-9 rating value and total therapy hours, (2) 1-9 rating value and duration of vocalizations, and (3) hearing level and duration There was no measurable relationship between the 1-9 rating values and I.Q

Verbo-tonal audiograms were obtained, utilizing filtered-speech testing In addition hearing aid usage was evaluated.

The electrical and acoustic responses of the Suvag I unit indicated that it passes more low-frequency energy than the Warren unit The Mini Suvag hearing aid passes more low-frequency energy than the Zenith Vocalizer II Designs of "new" electronic systems for measuring the speech pattern are discussed

A rehabilitation program for children and adults has been implemented which utilizes Verbo-tonal procedures. Marked improvements in speech discrimination scores have been demonstrated in some subjects within months Examples of cases are presented and discussed.

A 6-week Rebus reading program was introduced to four preschool deaf children. Noticeable improvement in reading was observed. There was a correlation between phonemic reading errors and errors in auditory perception. The results of this program are encouraging.

Six of the preschool deaf children also attended a normal-hearing preschool program. This Integration Program attempted to evaluate and modify behavioral interaction among the children.

The results of related research projects are presented. These include convention papers and abstracts of Master's theses.

This report is an Interim Report and no conclusions should be formulated until the final report has been submitted and approved.

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CHAPTER I

INTRODUCTION

On September 1, 1967, the Verbo-tonal Method was introduced and implemented in the Preschool Deaf Program at the University of Tennessee. On June 1, 1969, a three-year research grant from the U.S. Office of Education was approved to evaluate the effectiveness of low-frequency amplification and filtered speech testing for preschool deaf children. The specific aims as indicated on pages 10 and 11 of the original proposal are as follows:

(1) To compare the *rate* of vocalization of preschool deaf children who receive aural stimulation from auditory training units that have: (a) low-frequency response (0.5-20,000 Hz) or (b) "conventional" frequency response (300-3500 Hz).

(2) To compare the *quality* of vocalization of preschool deaf children who receive auditory stimulation under condition "a" or "b", as mentioned above.

(3) To compare the *auditory perception* of preschool deaf children who receive auditory stimulation under conditions "a" or "b". Auditory perception will be measured in an unaided free-field condition and an aided condition (amplification from "a" or "b" units).

(4) To compare the detection thresholds of preschool deaf children as tested by "conventional" pure-tone audiometric procedures and filtered-speech testing procedures. These thresholds will be compared at different stages of habilitation to evaluate if these children "learn to listen" and make maximum use of their residuum of hearing.

(5) To compare Sonographic analyses (Kay Electric, Model 6061A) of the speech samples which have been judged as "perceptually different" to determine possible correlations between the perceptual differences and acoustic differences.

(6) To develop a procedure for evaluating auditory training units with regard to frequency response, harmonic distortion, and intermodulation distortion.

(7) In addition, this project will attempt to stimulate, recruit, and "train" college students to be teacher-therapists of pre-school deaf children. The students will acquire the "new" therapy procedures and develop an ability to evaluate and utilize different auditory training units. At the end of the third year, a workshop will be conducted to disseminate the information from this project.

For twenty-one months prior to the research grant, the preschool program was in session on the basis of an 11-month school year for a limited number of children. During this period, recorded speech samples were obtained at 4-month intervals or three times each year. Table 1 displays the dates for each testing time which are identified as

TABLE 1

TESTING DATES PRIOR TO AND DURING THE RESEARCH PROJECT

11-Month School Year	Testing Times	Dates	Description
FIRST		Sept. '67	STARTED V.T. METHOD
	T_1	Dec. '67	Prior to Grant
	T_2	Mar. '68	" " "
	T_3	Jul. '68	" " "
SECOND	T_4	Oct. '68	Prior to Grant
	T_5	Feb. '69	" " "
		June '69	Grant Funded
	T_6	June '69	1st Fiscal Year (Experimental design not implemented at this point)
THIRD*		Sept. '69	EXPERIMENTAL DESIGN IMPLEMENTED
	T_7	Oct. '69	1st Fiscal Year
	T_8	Mar. '70	" " "
	T_9	Jul. '70	2nd Fiscal Year
FOURTH	T_{10}	Oct. '70	2nd Fiscal Year
	T_{11}	Apr. '71	" " "
	T_{12}	Jul. '71	3rd Fiscal Year
FIFTH	T_{13}	Dec. '71	3rd Fiscal Year
		Mar. '72	INTERIM REPORT

* Most of the statistical analyses in this Interim Report will apply to T_7, T_8, and T_9; some analyses will include T_{10}; some graphs on individual subjects may include measures from T_1 to T_{13}.

T_1 through T_5. After the grant was funded on June 1, 1969, auditory units, hearing aids, and other instruments were purchased. During the month of August, the training units were assembled in the classrooms, and on September 1, twenty-five preschool deaf children began receiving stimulation according to the requirements of the experimental design for this project. Recorded speech samples were obtained regularly at four-month intervals throughout each school year. The lower portion of Table 1 identifies the recording dates of T_7 through T_{13} which includes the samples that were obtained from the outset of the research project up to the time of this Interim Report. During the first fiscal year of the grant, the recorded samples (T_1 through T_6) that were obtained prior to September 1, 1969, were judged and analyzed with special emphasis on children who continued in the program after T_6.

This Interim Report will concentrate on the samples obtained at T_7, T_8, and T_9 which covered the period of the last three-quarters of the first fiscal year and the first-quarter of the second fiscal year. Other measures either before T_7 or after T_9 will be reported as they are available on individual children. In general, the processing of these samples is very time consuming, and the analyses are usually one year behind the obtaining of these samples.

As indicated earlier, six specific aims were formulated in the original research proposal. This Interim Report will provide data on all of these aims except number six. In addition, data will be reported on other criterion measures that have been added to help answer some of the basic questions of this research project. The data that is reported should be viewed only as interim data, and no final conclusions should be drawn until the Final Report is available.

This report is organized in main sections or chapters. The chapters in the first part of the report are somewhat dependent upon each other for basic information. The latter chapters, in general, are less dependent and can be read out of context. The reader is encouraged to refer to the Table of Contents for an overall view of the report.

The second chapter discusses the experimental procedures with a special section on Subjects. The reader should refer to this section and Table 1 to understand the identification of the subjects in this report

In order that the reader may have a better understanding of the purpose for evaluating low-frequency amplification, the following is a brief discussion of the rationale of this project.

Rationale

Surveys by Huizing (1959) and by Watson (1961) indicate that between 95 and 97 per cent of the children enrolled in schools for the deaf had some measurable hearing, usually below 500 Hz. These results are encouraging with respect to the possibility of utilizing low-frequency amplification to improve the speech patterns of deaf children. However, there appears to be some controversy with respect to the optimum frequency response for habilitating children. For example, the Jay L. Warren Company, one of the oldest manufacturers of auditory training units, whose units are probably the most accepted by educators of the deaf, presents this view on frequency response:

> "Although this subject has always been controversial, it is recognized that useful elements of speech communication are between 300 and 3500 Hz . . . For greater intelligibility the frequency response of the T-2 is therefore tailored to those communication frequencies . . . We have found through teaching in the field that high-frequency squeals and low-frequency room rumble contribute nothing to the voice communication, while they detract seriously from the training program."

In contrast with this philosophy, Petar Guberina, who developed the Verbo-tonal Method, indicates that an extended low-frequency response is essential for developing and improving the intonations and rhythmical patterns of the speech of congenitally-deaf children. As a result, the Verbo-tonal Method utilizes auditory training units with an electrical frequency response that extends from 1/2 to 20,000 Hz.

The philosophy for constructing the Warren unit appears to accurately reflect the philosophy within the U.S.A. with regard to the effectiveness of low-frequency amplification. It has been demonstrated through various research projects that low-frequency ambient noise does create a masking in terms of perceiving speech. With the proper transducers the masking from low-frequency ambient noise can be minimized. For example, a microphone that is directional and can be used within a range of three to six inches from the lips will produce a favorable signal-to-noise ratio and reduce the effect of ambient noise.

Another point to consider is low-frequency speech energy. Guberina contends that low-frequency speech energy does not mask high-frequency speech energy but rather facilitates perception of it. He believes that this is especially important for congenitally-deaf children who are in the process of developing normal intonation and rhythmical patterns for speech. After the child has developed the proper rhythm and intonation patterns, he should be able to develop more intelligible speech patterns. After a certain degree of intelligible speech has been achieved, low-frequency speech energy is not as important for the child as it was earlier. In fact, the low-frequency energy can be attenuated and the ear can structure this information although it is not physically present. An example of this is the phenomenon whereby the pitch of a complex signal can be perceived even though the fundamental frequency has been attenuated. If Guberina's hypothesis is correct, conventional auditory units (such as the Warren unit) reduce the chances that a deaf child will develop normal speech production and auditory perception.

On the other hand, the philosophy of the Warren Company suggests that deaf children trained on low-frequency auditory units would perform less well than children trained on conventional units. These conflicting philosophies make it difficult, if not impossible, to select the frequency response that would be optimal for habilitating most preschool deaf children. This research project addresses itself to a very basic question: Do different frequency responses in auditory training units and hearing aids have a significant effect on the habilitation of preschool deaf children? If this basic question is answered by the results of this project, it would then be necessary to search further to find the most appropriate or optimal frequency response. The outcome of this project is especially important because most habilitation programs are not able to develop a high quality of auditory perception and speech production in their deaf children. This failure may be a consequence of both the lack of the optimal frequency response and also the most appropriate habilitation procedures for making maximum use of residual hearing. As a result, identifying the optimal frequency response and techniques may encourage the teacher to work more intensely to develop auditory perception in deaf children.

The next chapter will discuss the experimental design, and the following chapters will present the results of criterion measures and other activities related to this research project.

CHAPTER II

EXPERIMENTAL PROCEDURE

Instrumentation

To evaluate the effectiveness of low-frequency amplification, the experimental design as displayed in Figure 1 was implemented to permit the teacher to speak simultaneously through two different amplifying systems, a low-frequency auditory training unit (Suvag I) and a conventional unit (Warren, model T-2). The microphones of both units were secured in one fixture. The Suvag unit utilized 4 Astatic cartridges, model MC-151, wired in parallel, and the Warren unit utilized a Shure microphone, model 777. To minimize problems in the classroom, the same type of output transducers were utilized for all children. Each training unit could independently excite 5 headsets (Koss, model SP-3XC) and 5 bone vibrators (Vibra Suvag, model 73). After the first fiscal year, Koss, model K-6 earphones were utilized in place of the model SP-3XC because the K-6 earphones provided a better seal and had a better low-frequency response. Three classrooms were instrumented with this identical design; each classroom was capable of handling ten children, five using the Suvag unit and five using the Warren unit. All teachers utilized the Verbo-tonal Method for habilitation; the experimental design attempted to control differences among teachers.

Two hearing aids were selected that produced frequency responses that were similar to the training units. The Mini Suvag hearing aid was assigned to the children on the Suvag I unit, and the Zenith Vocalizer II was assigned to the children on the Warren unit.

A Brüel and Kjaer test system set for a 20 millivolt RMS input signal was utilized to evaluate the training units. Figure 2 displays the electrical response of the pre- and power-amplifier of the Suvag I unit. The ordinate represents a 50 dB range. At -3 dB, the electrical response had no significant breakpoints; at -4 dB the response reached the limit of the B & K test system which is 20 to 20,000 Hz. In addition, a manual system with a low-frequency sine wave generator was employed to test the electrical response below 20 Hz. The amplitude of the signal was measurable until 1/2 Hz. The waveform as viewed on an oscilloscope did not exhibit visible distortion until 2 Hz. This electrical frequency response (1/2 to 20,000 Hz) is in agreement with the specifications indicated by the manufacturer of Suvag I units.

Figure 3 displays the electrical response of the Warren unit as measured by the B & K test system. At -3 dB, the electrical response extended from 300 to 7,000 Hz, and at -4 dB it extended from 280 to 8,000 Hz. The low end of this frequency response approximates specifications of the manufacturer; however, the high end of the frequency response extended beyond the 3500 Hz specifications of the manufacturer. These specifications may refer to the acoustical response rather than the electrical response.

To evaluate the acoustic response of both units, the same Koss earphone (model SP-3XC) was mounted on a flatplate that was coupled to a standard Brüel and Kjaer artifical ear (model 4152). The B & K test system provided the 20 millivolt RMS input signal to each training unit and the test earphone was connected to the training unit under test. Figure 4 displays the acoustic output response through the Suvag I unit. Figure 5

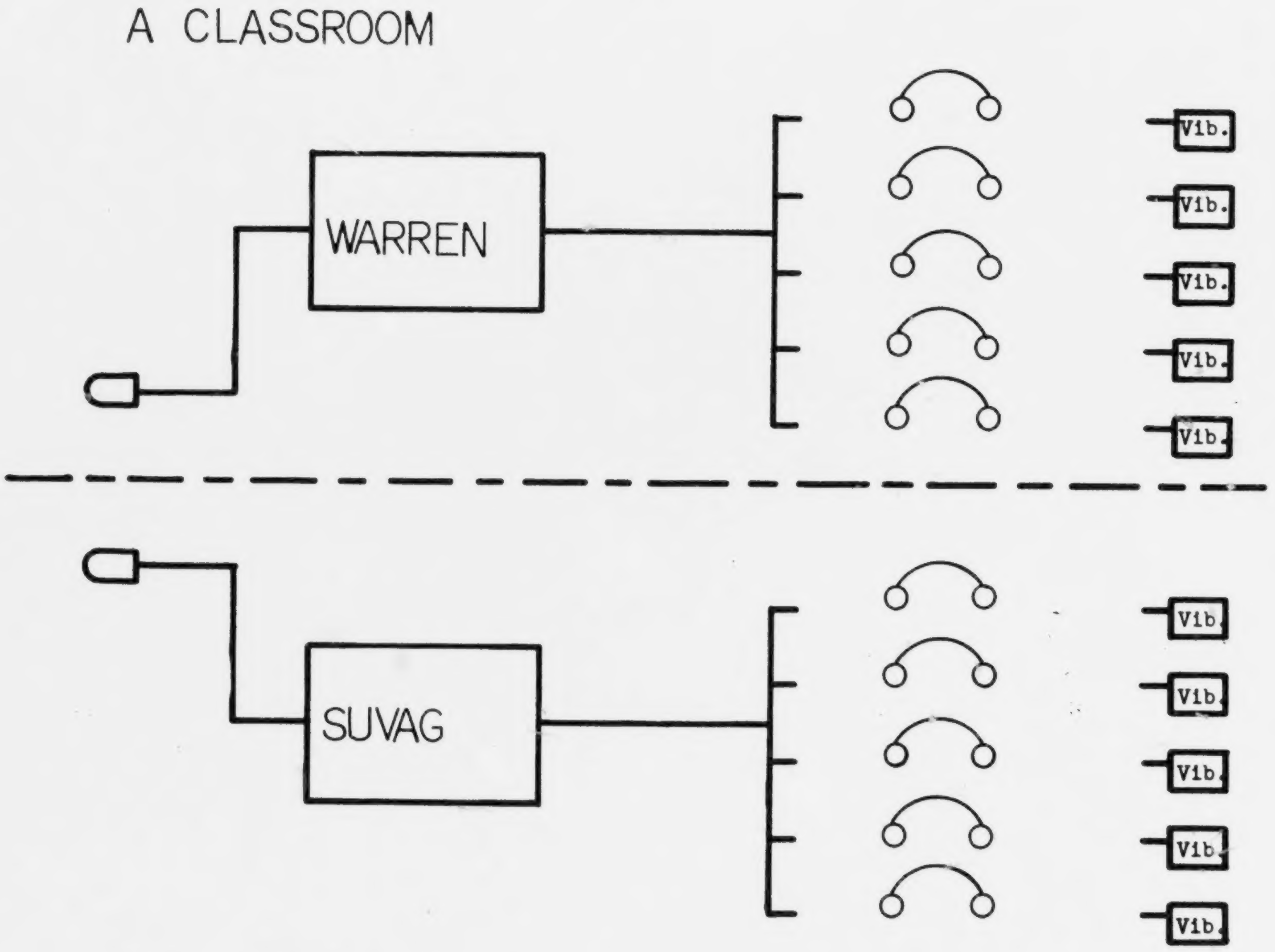
A CLASSROOM
WARREN
SUVAG
Vib.
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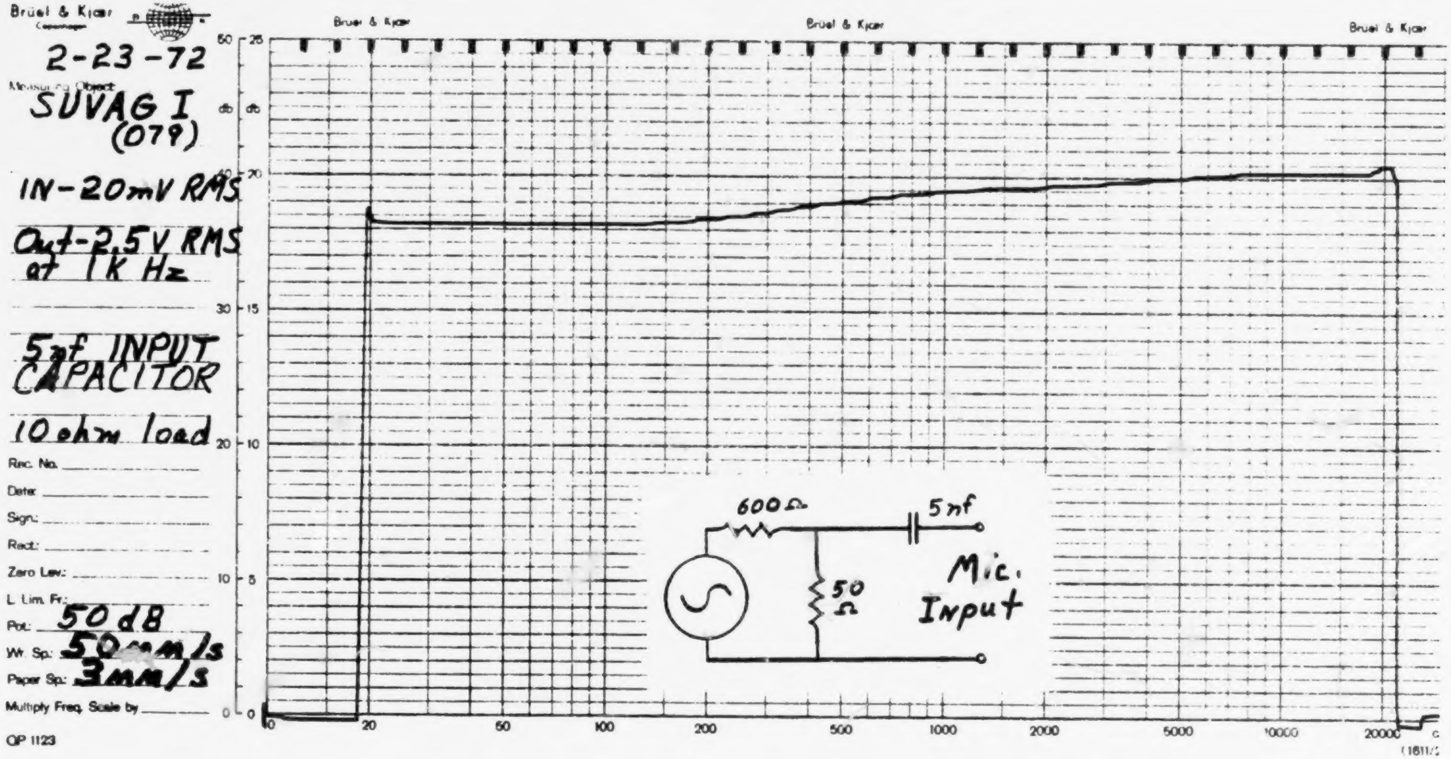
Figure 1· Instrumentation in a Classroom



Brüel & Kjær Copenhagen

2-23-72

Measuring Object: SUVAG I (079)

IN-20mV RMS

Out-2.5V RMS at 1K Hz

5nf INPUT CAPACITOR

10 ohm load

Rec. No.

Date:

Sign.:

Rect.:

Zero Lev.:

L. Lim. Fr.:

Pot.: 50 dB

Wr. Sp.: 50mm/s

Paper Sp.: 3mm/s

Multiply Freq. Scale by

QP 1123

Figure 2. Electrical Frequency Response of Suvag I, Serial No. 079.

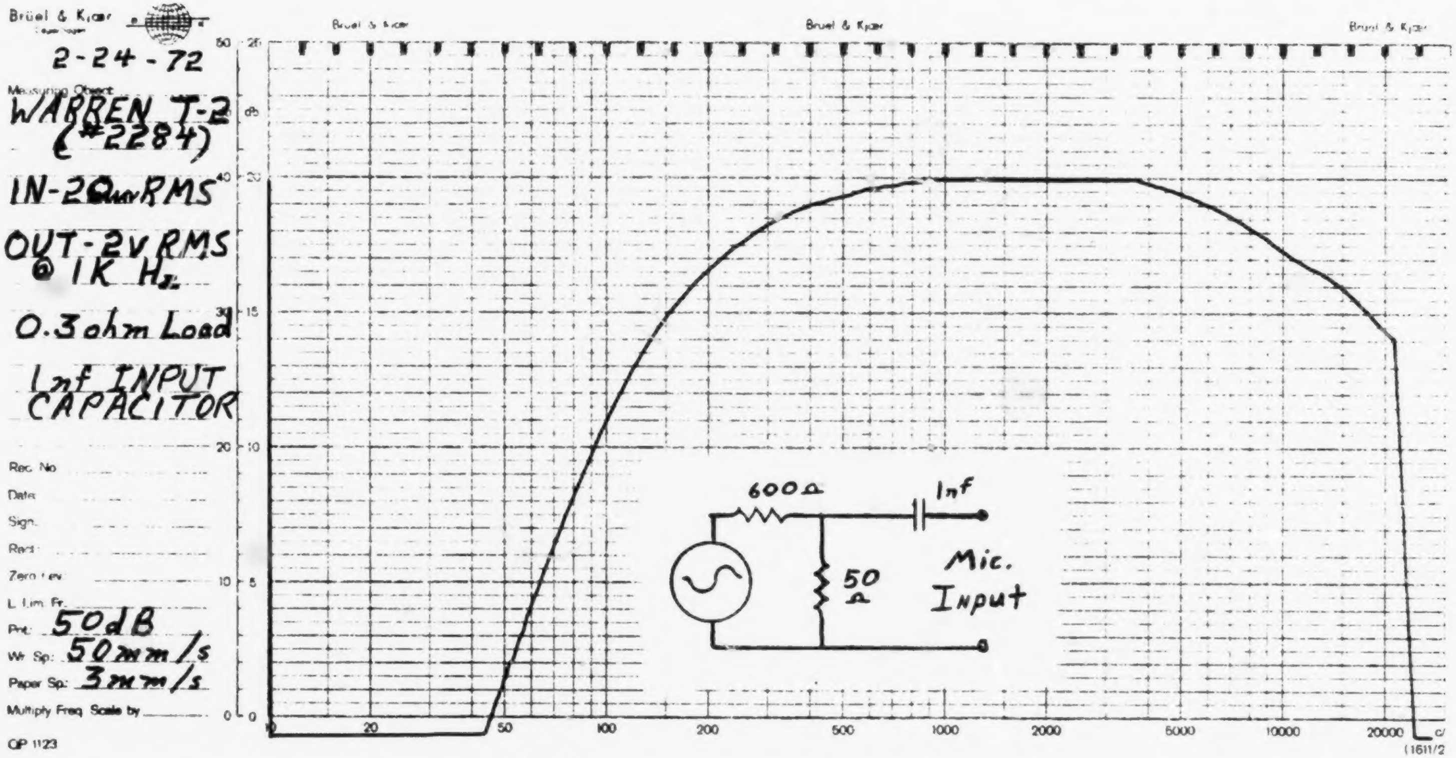
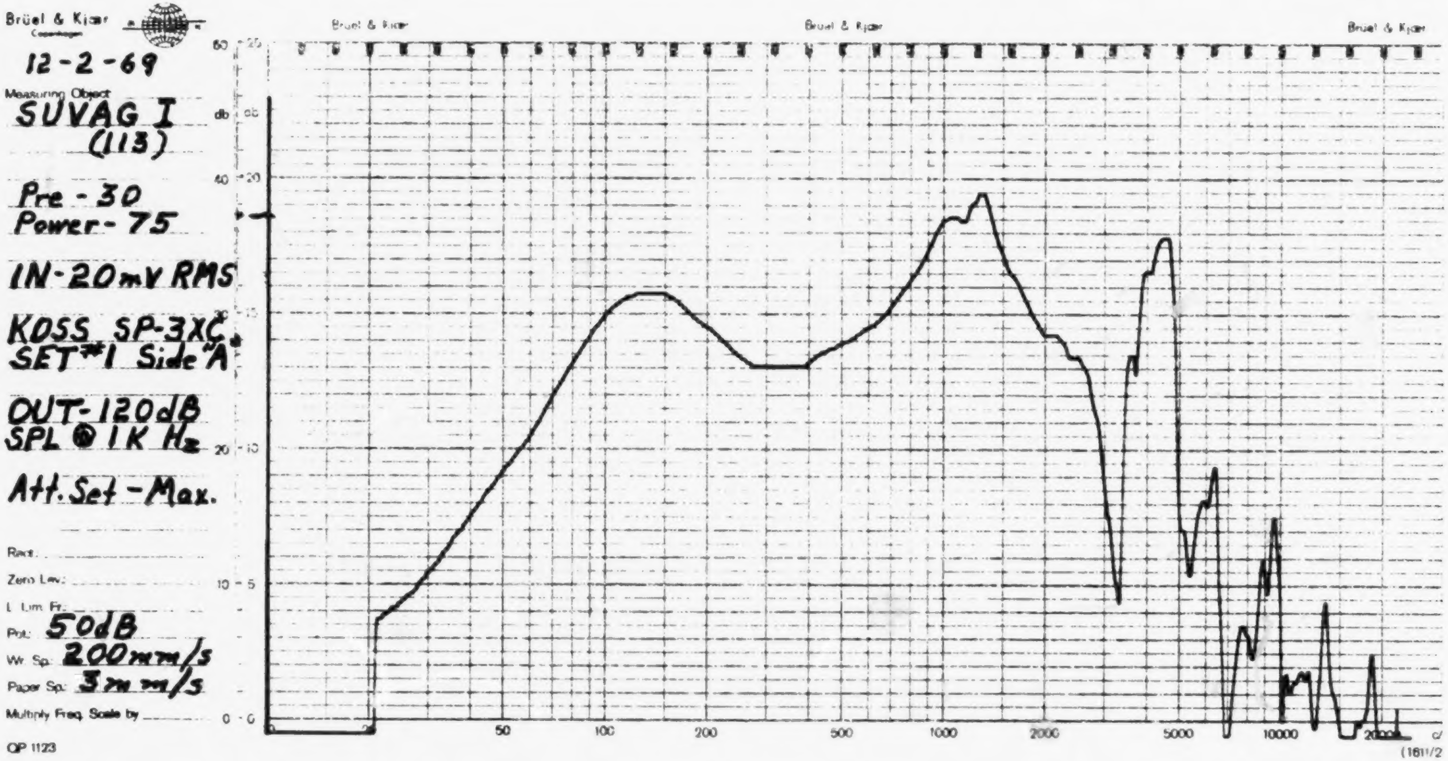


Figure 3. Electrical Frequency Response of Warren, Model T-2.



12-2-69

Measuring Object: SUVAG I (113)

Pre - 30
Power - 75

IN-20mV RMS

KOSS SP-3XC
SET #1 Side "A"

OUT-120dB
SPL @ 1K Hz

Att. Set - Max.

Rect.:
Zero Lev.:
L. Lim. Fr.:
Pot.: 50dB
Wr. Sp.: 200mm/s
Paper Sp.: 3mm/s
Multiply Freq. Scale by:

Figure 4. Electrical Input to Suvag I and Acoustic Output Through a Koss, Model SP-3XC Earphone.

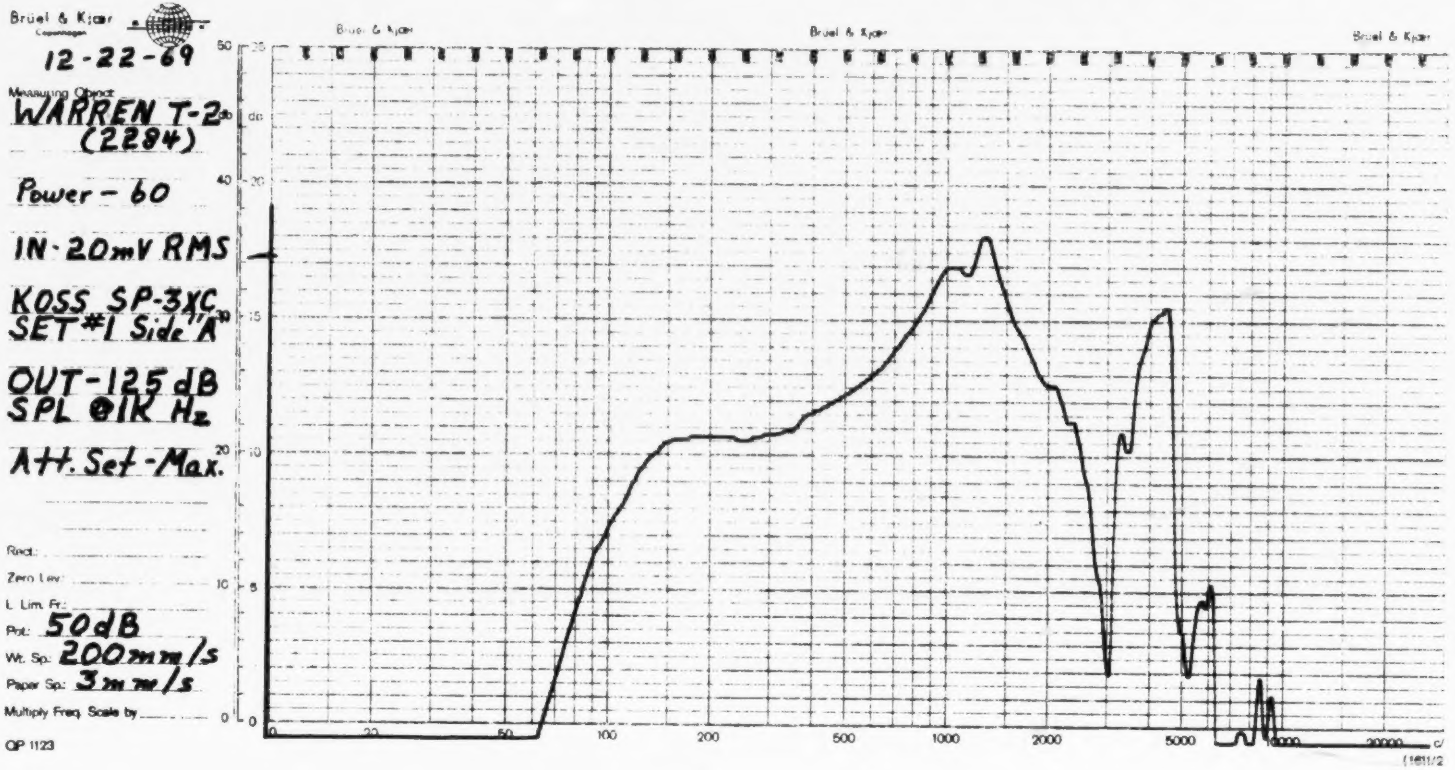


Figure 5. Electrical Input to Warren, Model T-2, and Acoustic Output Through a Koss, Model SP-3XC Earphone

displays the response through the Warren unit. The acoustic response of both units was similar for the high frequencies; however, the low-frequency unit produced a greater response below 500 Hz. When heard through the earphone, the low-pitched sound of the Suvag I unit is very obvious. The specification of the Koss SP-3XC earphone indicated a frequency response of 10 to 15,000 Hz; this "typical" earphone did not respond according to specifications. Although flatplate couplers produce reputable measures for evaluating circumarual earphones, the validity of these measurements may be questioned because of the acoustical problems in such an evaluation.

In September, 1970, the project design was altered by selecting a model K-6 Koss earphone to replace the model SP-3XC. This change was introduced because, in addition to a greater low-frequency response, and a better acoustical seal for the children, the Koss K-6 earphones were functionally much more desirable for classroom work. Figure 6 displays the acoustical response of the Suvag I unit through a test K-6 earphone. Figure 7 displays the acoustical response of the Warren unit through the same earphone. As can be observed in these two graphs, there is a greater acoustical difference in the low-frequency range.

A Brüel and Kjaer hearing-aid test box (Type 4212) was employed to evaluate both the Mini Suvag and the Zenith Vocalizer II. A 70 dB SPL input was utilized and the gain of each aid was set to achieve 100 dB SPL output at 1000 Hz. Figure 8 displays the acoustical response of the Mini Suvag; Figure 9 displays the response of the Zenith hearing aid. At -15 dB below the 3-frequency average of .5, 1 and 2 KHz (Lybarger, 1961), the frequency range of the Mini Suvag extended from 20 to 4000 Hz, whereas the Zenith was from 200 to 3500 Hz. For an additional evaluation, each hearing aid was placed in the center of an 8'x9' double-walled, sound-treated room (Suttle, model SE 224). A constant acoustic output from a speaker (Utah, model C12PC3B) was controlled by the Brüel and Kjaer test system, and the response of the aids was measured. In both the hearing-aid test box and the sound-treated room, the Mini Suvag had a wider frequency response than the Zenith aid.

A later chapter on "Evaluation of Instrumentation" will provide more information on these units.

Subjects

At the onset of this study, the Project Audiologist (Dr. Jane Madell), the Supervising Teacher (Mrs. Elsie French), and the Project Director assumed the responsibility of assigning the children to either the Suvag or Warren units. Dr. Madell evaluated the hearing level and Mrs. French evaluated the speech production and auditory perception of each child. A series of staff meetings was held to discuss all available diagnostic information and the potential of each child to participate in this experimental program. As a result, eight children were assigned to the Suvag I unit, and eight children were assigned to the Warren unit. These children will be identified as the Suvag B group and the Warren group. Considerable effort was expended to match these two groups without creating bias in either direction; however, it was impossible to predict how each of these children would respond to therapy throughout the entire year.

In addition, nine children who received stimulation on the Suvag I unit prior to the implementation of this research design (September 1, 1969) were continued on Suvag I because of their previous exposure to low-frequency

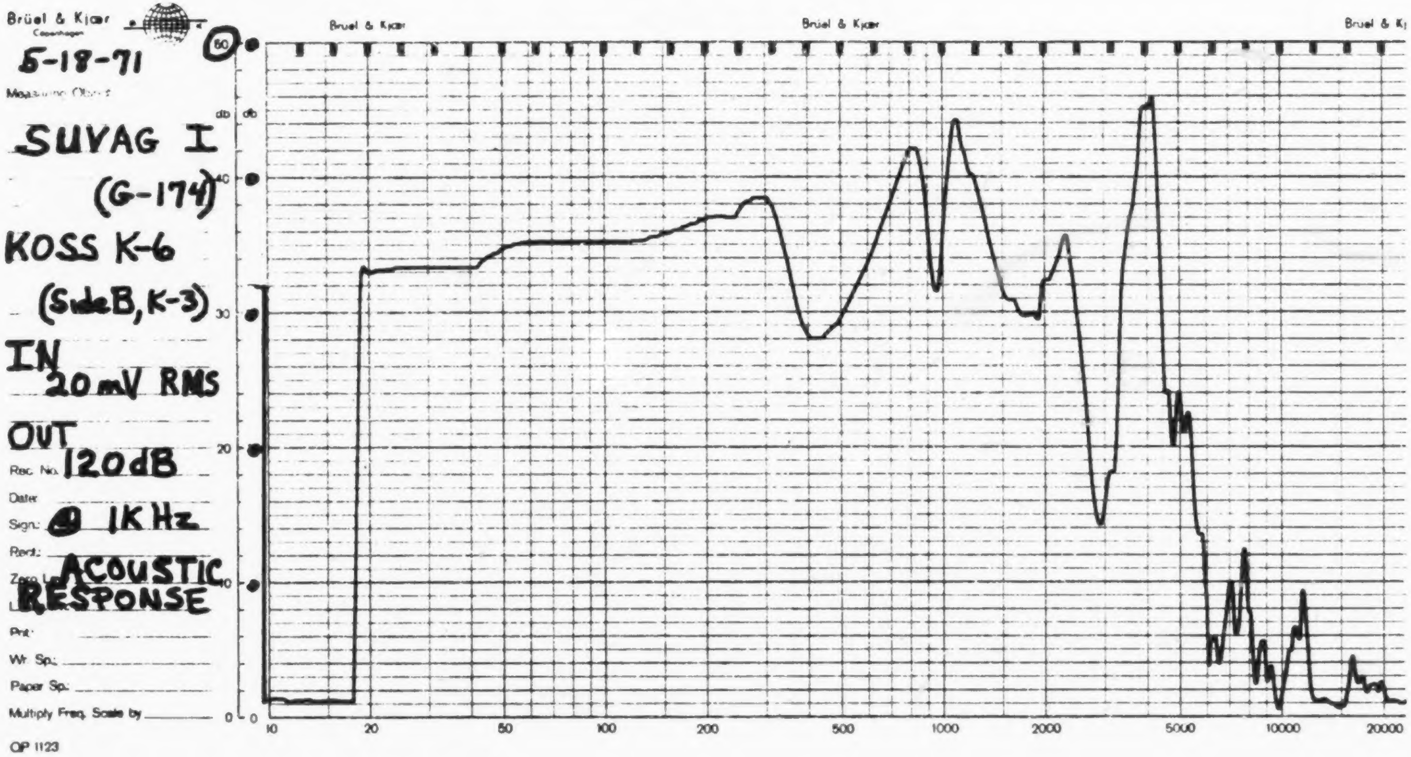


Figure 6. Electrical Input to Suvag I and Acoustic Output Through a Koss, Model K-6 Earphone.

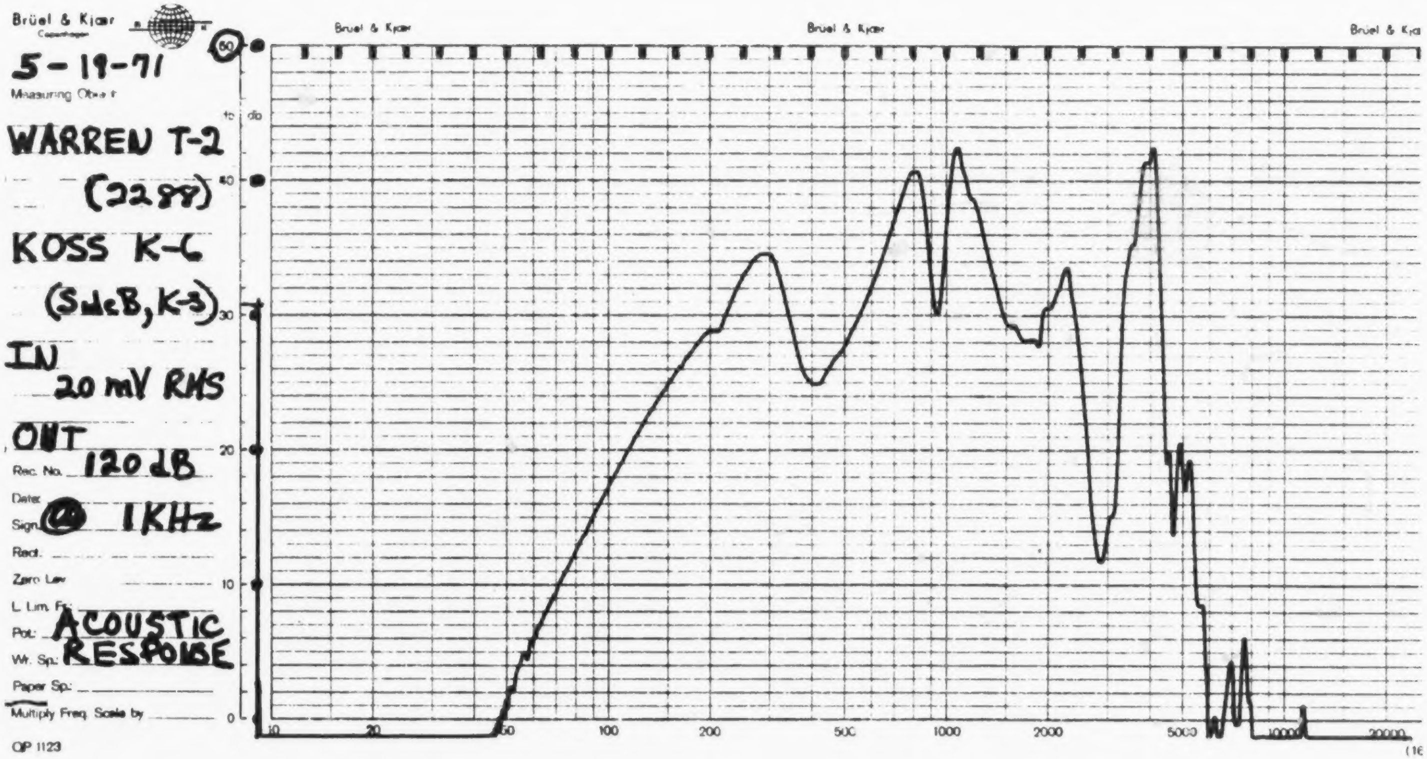
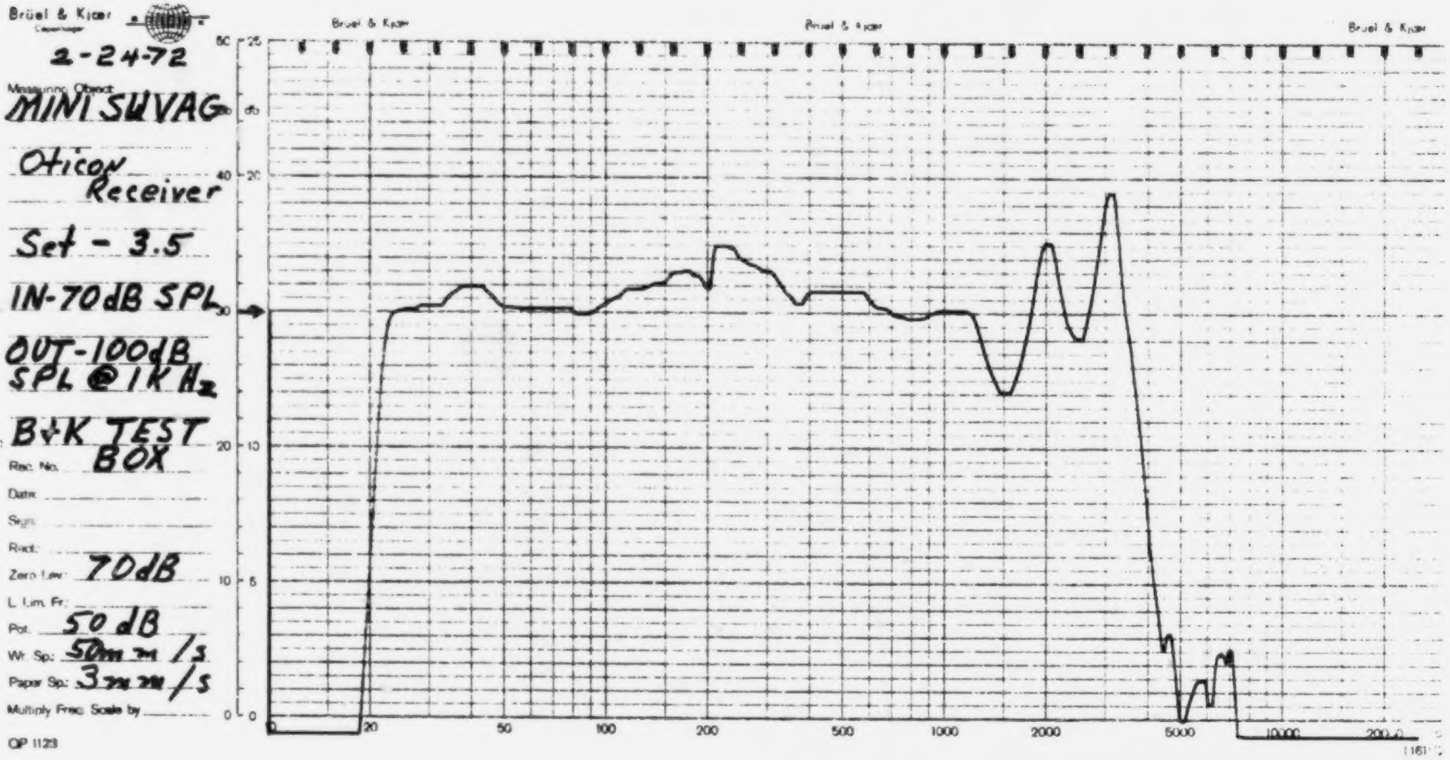


Figure 7. Electrical Input to Warren, Model T-2, and Acoustic Output Through a Koss, Model K-6 Earphone.



Brüel & Kjær Copenhagen

2-24-72

Measuring Object: MINI SUVAG

Oticon Receiver

Set - 3.5

IN-70dB SPL

OUT-100dB SPL @ 1K Hz

B+K TEST BOX

Rec. No.

Date

Sign

Rect.

Zero Lev: 70dB

L. Lim. Fr.

Pot: 50 dB

Wr. Sp: 50mm/s

Paper Sp: 3mm/s

Multiply Freq. Scale by

QP 1123

Figure 8. Mini Suvag Hearing Aid Evaluated in a Brüel and Kjaer Test Box

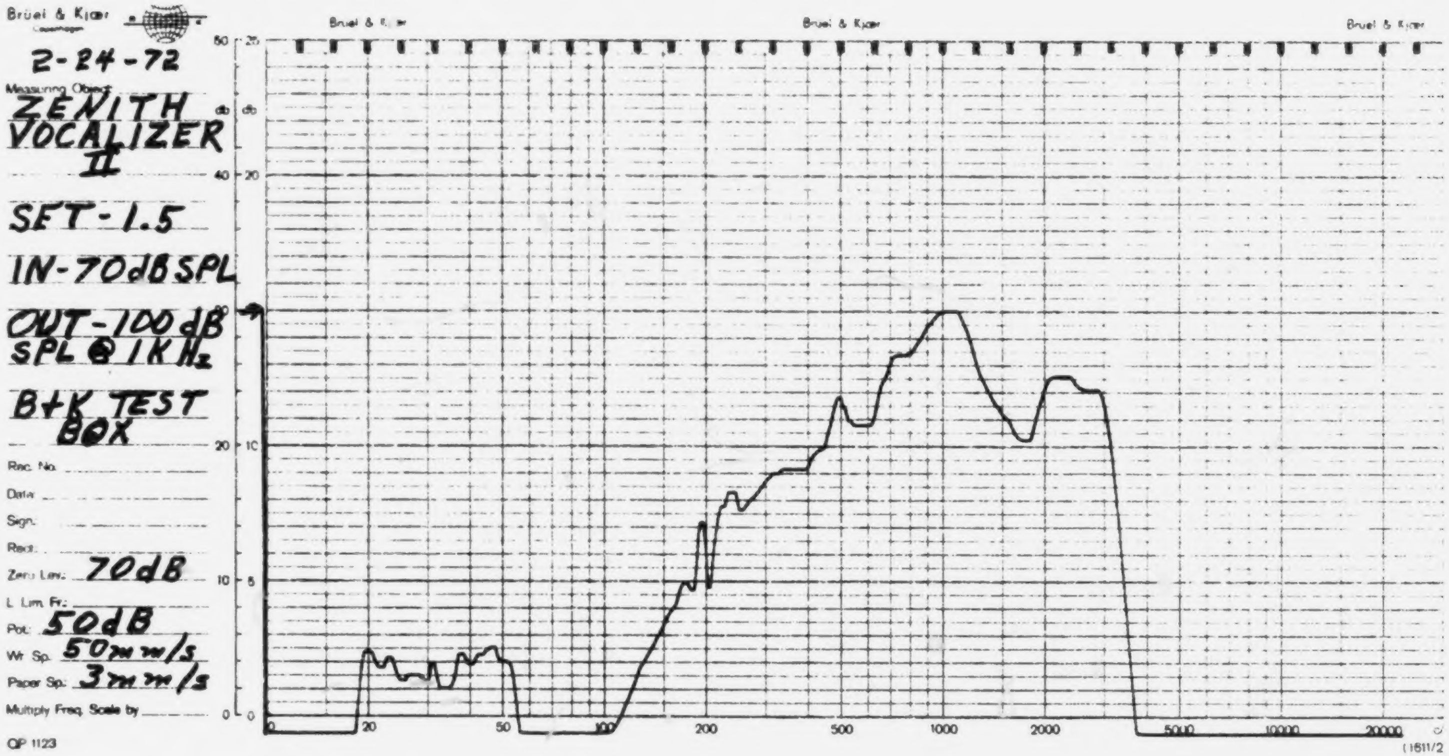

Brüel & Kjær
2-24-72
Measuring Object: ZENITH VOCALIZER II
SET-1.5
IN-70dB SPL
OUT-100dB SPL @ 1KHz
B+K TEST BOX
Rec. No.
Date
Sign.
Rect.
Zero Lev.: 70dB
L. Lim. Fr.:
Pot.: 50dB
Wr. Sp.: 50mm/s
Paper Sp.: 3mm/s
Multiply Freq. Scale by
QP 1123

Figure 9. Zenith Vocalizer II, Hearing Aid in a Brüel and Kjaer Test Box

stimulation. This group will be identified as Suvag A. As a result, measurements were obtained on 25 preschool deaf children. Nine children were in the Suvag A group, eight children were in the Suvag B group, and eight children were in the Warren group.

Table 2 identifies each subject according to a number (column one) that was assigned when the child entered the preschool program. The subject numbers in each subgroup are as follows: Suvag A -- 8, 9, 11, 14, 15, 16, 17, 19, 20; Suvag B -- 22, 25, 27, 28, 29, 39, 41, 42; and Warren -- 24, 26, 31, 33, 35, 36, 37, 38. Throughout this report these subjects will always be identified by these numbers. This includes information in tables, figures, and the text.

To the right of each subject number and within brackets, the group each subject belongs to is identified as Suvag (S) or Warren (W). In addition, Suvag A is identified as (S_a) and Suvag B as (S_b). An example of subject identification is as follows: S_8 (S_a); S_{22} (S_b); and S_{24} (W). Subjects will always be identified by subject number and group identification within the bracket as displayed in Table 2. Throughout this report this identification will be used for tables, figures, audiograms, the text, etc.

In the second column, Table 2 includes the initials for each subject for internal use only, and column three identifies the sex of each subject. Suvag A had 3 females and 6 males; Suvag B had 3 females and 5 males; and Warren had 6 females and 2 males. Sex was not utilized as a major factor in matching subjects for assignment to either group. As a result, the Warren group had more females than either Suvag group.

All children were scheduled and attended daily therapy sessions. The older children were scheduled for 3 hours daily or 15 hours per week. The younger children were scheduled for only 1½ hours per day or 7½ hours per week. The number of therapy hours for the younger children was increased throughout the year as they became capable of profiting from the stimulation. As a result, the number of therapy hours per week ranged between 7½ and 15 hours. With three classrooms available in the morning and three classrooms available in the afternoon, each child's class assignment was determined by his level of speech production and auditory perception. The number of children in each classroom ranged between three and six. Each classroom had at least one Suvag and one Warren child; the goal was always an equal number of Suvag and Warren children in each class. Throughout the school year (September, 1969, to August 1, 1970) the children were continually evaluated by the staff with regard to their success. If a child could function better at a higher or lower level, the child was moved to a class that would be optimum for learning. Changes in class assignment usually occurred three times each year. These changes were necessary to satisfy the teachers and the parents.

Tables 3a, 3b, and 3c display pertinent information for Suvag A, Suvag B, and Warren groups, respectively. As in Table 2, each subject is identified by subject number.

Column two of Tables 3a, 3b, and 3c identifies the ages of each child in years and months. The mean ages of each group as of September, 1969, were as follows: 4 years, 10 months for Suvag A; 3 years, 9 months for Suvag B; and 3 years, 10 months for the Warren group. Suvag A was the oldest group; the mean ages for Suvag B and Warren were similar.

TABLE 2

SUBJECT NUMBER AND AMPLIFYING SYSTEM, SUBJECT INITIALS, AND SEX

GROUP	SUBJECT NO.	INITIALS	SEX
Suvag A	S_8 (S_a)	T.Z.	F
	S_9 (S_a)	K.C.	F
	S_{11} (S_a)	K.B.	M
	S_{14} (S_a)	D.D.	M
	S_{15} (S_a)	P.R.	M
	S_{16} (S_a)	T.E.	F
	S_{17} (S_a)	M.P.	M
	S_{19} (S_a)	K.F.	M
	S_{20} (S_a)	S.L.	M
Suvag B	S_{22} (S_b)	P.D.	F
	S_{25} (S_b)	C.S.	M
	S_{27} (S_b)	T.K.	F
	S_{28} (S_b)	H.S.	F
	S_{29} (S_b)	J.S.	M
	S_{39} (S_b)	D.P.	M
	S_{41} (S_b)	T.S.	M
	S_{42} (S_b)	J.P.	M
Warren	S_{24} (W)	M.W.	M
	S_{26} (W)	D.C.	F
	S_{31} (W)	D.B.	M
	S_{33} (W)	S.E.	F
	S_{35} (W)	S.M.	F
	S_{36} (W)	M.C.	F
	S_{37} (W)	A.O.	F
	S_{38} (W)	S.L.	F

TABLE 3a

SUVAG A GROUP: SUBJECT NUMBER AND AMPLIFICATION SYSTEM, AGE IN YEARS AND MONTHS, ETIOLOGY, LEITER I.Q. SCORES, AVERAGE HEARING LEVELS IN THE BETTER EAR, THERAPY HOURS DURING T_{7-9}, AND TOTAL THERAPY HOURS IN PROGRAM

Subj. No. and Grp.	Age	Etiology	I.Q.	Average HTL Better Ear		Therapy Hours T_{7-9}			Total Hours in Program
				2 freq.	3 freq.	Scheduled	Attended	% of Att.	
S_8(Sa)	5-7	Inf.	107	90	92	510	354	69	701
S_9(Sa)	4-4	Rub.	125+	60	62	533	343	64	501
S_{11}(Sa)	4-9	Rub.	91	65	67	440	384	87	517
S_{14}(Sa)	5-1	Unk.	88	88	91	533	465	87	559
S_{15}(Sa)	5-2	Unk.	100	85	93	392	245	63	372
S_{16}(Sa)	4-10	Rub.	90	105	105	547	333	61	385
S_{17}(Sa)	5-0	Rub.	*120	90	95	542	481	89	775
S_{19}(Sa)	4-6	Unk.	112	90	98	443	365	82	529
S_{20}(Sa)	4-3	Men.	113	97	100	404	268	66	325
MEAN	4-10		105	86	89	483	360	74	518
RANGE	4-3 to 5-7		88 to 125+	60 to 105	62 to 105	392 to 547	245 to 481	61to 89	325 to 775

* = Mean of more than one test score

KEY: Inf. = Infection
Rub. = Rubella
Unk. = Unknown
Men. = Meningitis

TABLE 3b

SUVAG B GROUP: SUBJECT NUMBER AND AMPLIFICATION SYSTEM, AGE IN YEARS AND MONTHS, ETIOLOGY, LEITER I.Q. SCORES, AVERAGE HEARING LEVELS IN THE BETTER EAR, THERAPY HOURS DURING T_{7-9}, AND TOTAL THERAPY HOURS IN PROGRAM

Subj. No. and Grp.	Age	Etiol-ogy	I.Q.	Average HTL Better Ear		Therapy Hours T_{7-9}			Total Hours in Program
				2 freq.	3 freq.	Sched-uled	Attend-ed	% of Att.	
S_{22}(Sb)	3-10	Rub.	90	75	77	368	308	84	314
S_{25}(Sb)	2-9	Unk.	84+	88	90	319	160	50	160
S_{27}(Sb)	3-8	H.F.	98	110	110	230	151	66	153
S_{28}(Sb)	2-10	Rub.	111	95	98	329	208	63	220
S_{29}(Sb)	3-5	Unk.	98	93	95	350	201	57	214
S_{39}(Sb)	5-11	Here.	NA	63	63	274	153	56	153
S_{41}(Sb)	4-9	Rub.	85+	68	73	165	142	86	142
S_{42}(Sb)	2-9	Here.	NA	80	83	171	98	57	98
MEAN	3-9		94	88	86	276	178	65	182
RANGE	2-9 to 5-11		84+ to 111	63 to 110	63 to 110	165-368	98 to 308	50 to 86	98 to 314

KEY:
NA = Not Available
Rub. = Rubella
Unk. = Unknown
H.F. = High Fever
Here.= Heredity

TABLE 3c

WARREN GROUP: SUBJECT NUMBER AND AMPLIFICATION SYSTEM, AGE IN YEARS AND MONTHS, ETIOLOGY, LEITER I.Q. SCORES, AVERAGE HEARING LEVELS IN THE BETTER EAR, THERAPY HOURS DURING T_{7-9}, AND TOTAL THERAPY HOURS IN PROGRAM

Subj. No. and Grp.	Age	Etiol-ogy	I.Q.	Average HTL Better Ear		Therapy Hours T_{7-9}			Total Hours in Program
				2 freq.	3 freq.	Sched-uled	Attend-ed	% of Att.	
S_{24}(W)	3-0	Prem.	NA	85	90	310	102	33	104
S_{26}(W)	1-10	Unk.	133	100	102	304	201	66	201
S_{31}(W)	4-10	Here.	NA	75	77	532	361	68	361
S_{33}(W)	4-10	Unk.	82	110	110	291	122	42	122
S_{35}(W)	3-10	Unk.	126+	88	93	544	487	90	487
S_{36}(W)	4-7	Rub.	62	80	82	503	161	32	161
S_{37}(W)	4-7	Unk.	NA	50	70	492	376	76	376
S_{38}(W)	3-10	H.F.	NA	N/A	N/A	206	176	85	182
MEAN	3-10		101	87	89	398	248	62	249
RANGE	1-10 to 4-10		62 to 133	50 to 110	70 to 110	206 to 544	102 to 487	32 to 90	104 to 487

KEY: NA = Not Available
N/A = No reliable results available
Prem. = Prematurity (Rh)
Unk. = Unknown
Here. = Heredity
Rub. = Rubella
H.F. = High Fever

The project audiologist attempted to obtain a minimum of three reliable pure-tone audiograms during each 11-month school year. The most recent and/or the most reliable audiogram for each child is displayed in Appendices A-1 through A-9 (Suvag A), B-1 through B-8 (Suvag B), and C-1 through C-8 (Warren). Each audiogram is identified by initials, subject number, and group assignment. In addition to the plotted detection thresholds, 3-frequency (500, 1000, and 2000 Hz), 2-frequency (best two of 500, 1000, and 2000 Hz), and low-frequency (125 and 250 Hz) averages are displayed at the bottom of each audiogram. The three- and two-frequency average for each subject is also listed in columns five and six of Tables 3a, 3b, and 3c. The mean two-frequency average for each group was as follows: 86 dB for Suvag A, 88 dB for Suvag B, and 87 dB for the Warren group. The groups appeared similar in hearing level.

The Leiter International Performance Scale was utilized to evaluate the I.Q. of each child in this study. Dr. Bernard Silverstein, Professor of Speech Pathology and qualified with a Certificate of Clinical Competence in Speech Pathology, administered these tests. It was not possible to obtain a test score on each child because of schedule problems. Tables 3a, 3b, and 3c display the Leiter I.Q.'s that were available at the time of this report. The mean I.Q. for each group was as follows: 105 for Suvag A, 94 for Suvag B, and 101 for the Warren group. Most of the children appeared to be functioning within normal limits.

The etiology of the hearing loss was determined by the project audiologist, Dr. Jane Madell. This information is displayed in Tables 3a, 3b, and 3c. Table 4 displays the same information according to the number of subjects within each etiology. The Suvag A and B groups had the most rubella cases. Thirty-six percent of the children had unknown etiologies. The type of etiology, the area affected, and the extent of damage are probably very crucial factors in determining the prognosis of each child to benefit from auditory training. It is frustrating not to know the affect of these factors on each child.

The project secretary maintained daily records of the attendance. Tables 3a, 3b, and 3c display the therapy hours scheduled and attended for each child for the 1969-70 school year. Because the Suvag A group had some stimulation prior to September, 1969, these tables also include the total therapy of each child in this program. Figure 10 displays the mean and the range of therapy hours for each group. The broken vertical lines represent the range for each group for the 1969-70 school year. For the 1969-70 school year, Suvag A received a mean of 339 hours, Suvag B received a mean of 176 hours, and Warren received a mean of 235 hours. As can be observed, the Warren group received more hours than did the Suvag B group. The solid vertical line displays the range of hours for the total time in the preschool program. The Suvag A group's relatively greater number of hours is attributable to the fact that they received therapy before September 1, 1969.

As indicated earlier the Mini Suvag hearing aid was selected for children on the Suvag I unit, and the Zenith Vocalizer II was selected for the children on the Warren unit. The project audiologist, Dr. Jane Madell, completed a hearing evaluation on each child to determine if he could benefit from the use of the hearing aid. In addition, the classroom teacher of each child evaluated the child's potential to utilize a hearing aid for monitoring speech. The project audiologist and the

TABLE 4

DISTRIBUTION OF ETIOLOGIES OF HEARING LOSS WITHIN GROUPS

Etiologies	Suvag A	Suvag B	Warren
Rubella	4	3	1
Heredity	0	2	1
High Fever	0	1	1
Infections	1	0	0
Meningitis	1	0	0
Prematurity (Rh Factor)	0	0	1
Unknown	3	2	4
N =	9	8	8

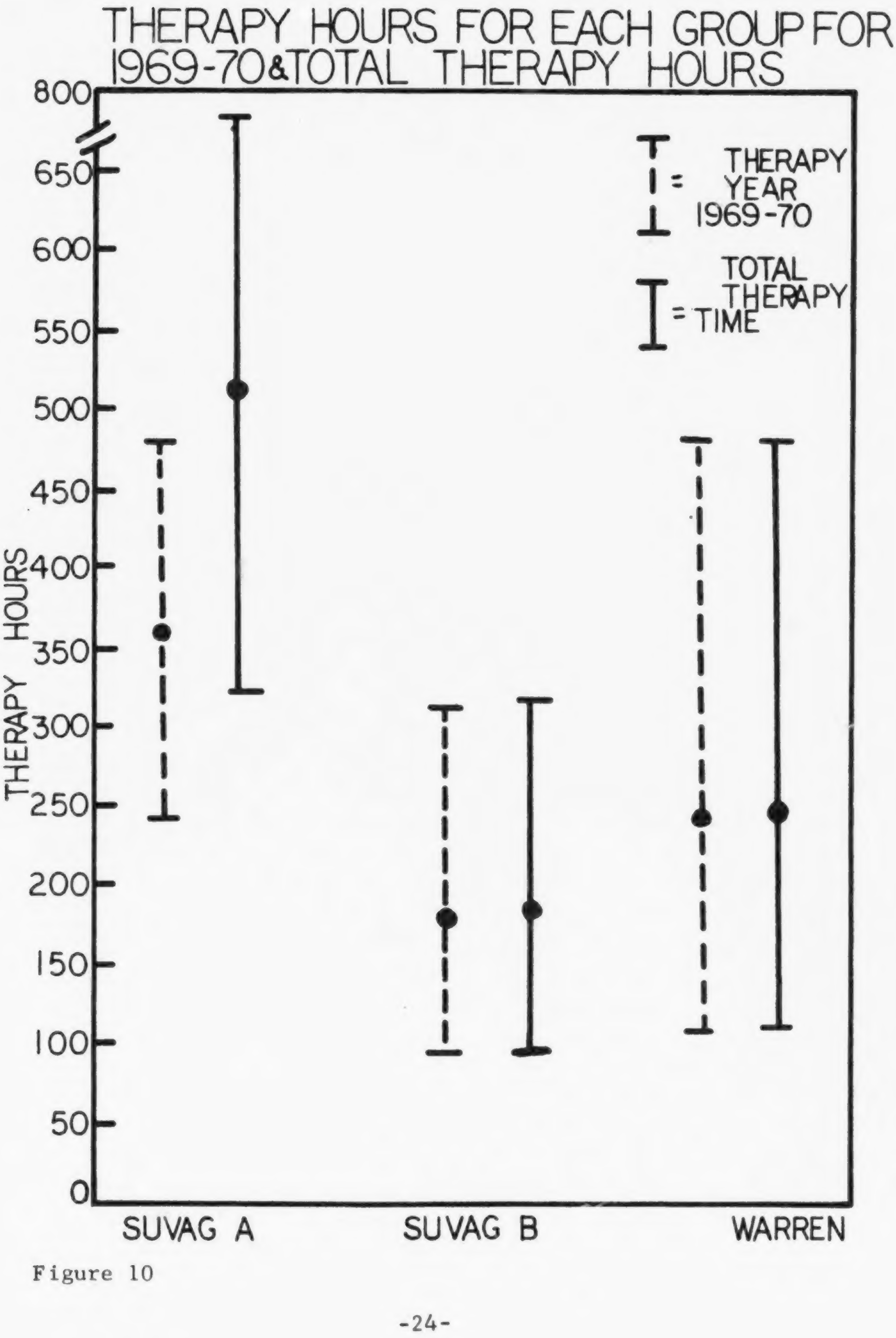

THERAPY HOURS FOR EACH GROUP FOR 1969-70 & TOTAL THERAPY HOURS
800
650
600
550
500
450
400
350
300
250
200
150
100
50
0
THERAPY HOURS
= THERAPY YEAR 1969-70
= TOTAL THERAPY TIME
SUVAG A
SUVAG B
WARREN

Figure 10

classroom teacher discussed the feasibility of hearing aid placement. Our criterion was that each child be able to detect the speech signal through the hearing aid and utilize the acoustic signal to improve his communication ability. As a result, a hearing aid was assigned to each child as he became a "good candidate" for wearing a hearing aid. Suvag I children were assigned the Mini Suvag hearing aids and the Warren children were assigned the Zenith Vocalizer II hearing aids.

Figure 11 displays the mean number of hours of hearing aid use per week for each group for the period September 1, 1969 to August 1, 1970. A dot indicates the mean number of hours for each group and the vertical line indicates the range within each group. The mean number of hours for the Suvag A group was 43; for the Suvag B group it was 45; and for the Warren group it was 56. The Warren group wore the hearing aid approximately 12 hours more per week than did the Suvag group. The number of hours the children wear the hearing aids can be affected by various factors. It is important that a parent encourage the child to wear the aid and that he or she be very alert to any malfunction of it. It was suspected that some parents were reporting more hours than the aid was worn. They may have felt guilty for not encouraging the child to wear the aid because use of it was an indication that the child was perceiving sound. However, some of the parents were very motivated and conscientious in following the recommendations of the staff.

Therapy Procedures

Since Mrs. Elsie French had been utilizing the Verbo-tonal Method prior to the research grant (September, 1967 - June, 1969), she was assigned the responsibility of supervising teacher and the training of new teachers. During the summer session with the children (June 15 - August 1, 1969), Mrs. Patricia Parlato and Miss Mary McClanahan were trained in the Verbo-tonal procedures. Mrs. Parlato had worked 10 hours per week in the Verbo-tonal classes during the previous year and had some experience in the program. On August 1, 1969, both of these teachers were employed full-time on the research grant. On September 1 of the same year, the experimental design was implemented and three full-time teachers assumed the responsibility of providing therapy for the children. On January 1, 1970, Mr. John Berry was awarded a half-time graduate assistantship and worked as a teacher assistant in the program.

In the training of the teachers, there was an attempt to have each teacher understand the principles of the Verbo-tonal Method and to utilize these principles in the classroom so that the therapy procedures would be similar for each class. In general the Verbo-tonal therapy was divided into four areas: (1) body movements and implementation, (2) musical stimulation, (3) reading readiness activities and (4) individual work. Body movements involved the use of body tension and movement to teach the correct tension for articulation. For example, the voiceless phoneme "pa" is more tense than the voiced cognate "ba". For teaching the tense "pa," the teacher would go from a position of less tension to a position of greater tension (e.g. stretching toward the ceiling). At the point of maximum tension, she would stimulate the child with the syllable "pa". On the other hand, for the syllable "ba", the teacher would go from a position of greater tension to a position of less tension and stimulate the child with the syllable "ba". In general the consonants were usually introduced in the initial position, but in some cases the final position was utilized (e.g., umm). From these syllables, words were developed

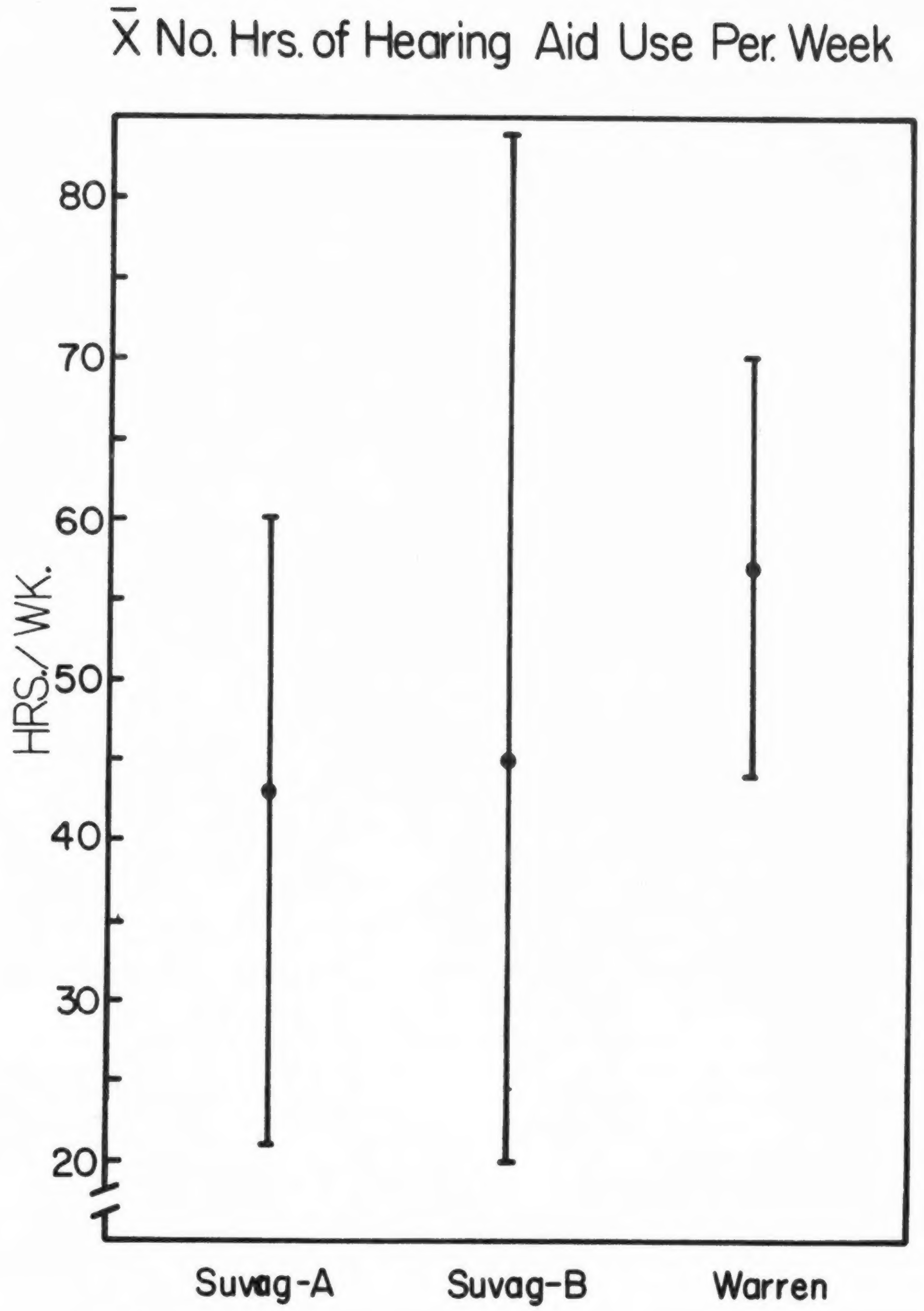

$\bar{X}$ No. Hrs. of Hearing Aid Use Per. Week
HRS./ WK.
80
70
60
50
40
30
20
Suvag-A
Suvag-B
Warren

Figure 11

utilizing the particular consonant in all three positions of a word. The body movements were adapted for each group and attempted to meet the needs of each child because some children were more tense than other children. The teachers attempted to use a variety of body movements so that one movement would not become a clue for a particular phoneme.

The implementation procedure was utilized as soon as a child could articulate the word. For example, the child would speak the word "up" as he climbed up a step This would allow the child to learn the concept of the word and hopefully begin to utilize it in meaningful communication. In most cases, the implementation was utilized within a body movement session when the child could articulate the word.

Musical (rhythmical) stimulations were utilized to teach the correct timing and rhythm of the syllables and words necessary for normal speech production, and to increase the auditory memory span of the children. In this procedure the children and the teacher would clap, tap, or make similar rhythmical movements together as they spoke in unison and practiced the nursery rhymes developed for this purpose.

Reading readiness activities, e.g., color matching, lotto games for concept formation, cutting and pasting, and number readiness were part of the total therapy program. During these activities, a multisensory approach was utilized with special emphasis on auditory input whenever it was appropriate. Visual clues were available, but formal lipreading was not utilized.

For the Verbo-tonal Method, individual work should be used in conjunction with group therapy. In individual work the child is taken from the group situation and receives individual attention for any problem which is hindering his progress within the group. Emphasis may be upon body movements and speech production, rhythmical stimulations, or associations and concept development. Auditory perception is developed in both an aided and unaided situation. Ideally, each child should receive individual stimulation daily, as it is considered to be an essential part of the Verbo-tonal Method. Due to our shortage of staff members, the children received individual therapy only 2-3 times per week.

Table 5 is an example of a 3-hour therapy procedure with an older class. As indicated earlier, the first hour was devoted to body movements and implementation. This was usually followed by a short break that was a free, unstructured play situation; however, a planned activity was used occasionally. After this rest period, the teacher utilized musical stimulation, reading readiness activities, and work on auditory perception in the form of drill games. Although our teachers had never received formal training from a Yugoslavian teacher, they appeared to be able to utilize basic principles of body tension in teaching and improving articulation. Rhythmical (musical) stimulation was not utilized on a regular basis because the teachers had less of an understanding and confidence in this procedure.

Whenever possible individual work was accomplished by two teachers sharing responsibilities. The last 30 minutes of the three-hour session were usually in the form of art activities or story telling.

The children wore Koss earphones (Model SP-3XC) approximately 75 percent of the time during the regular class session. Each teacher wore a shoulder harness that kept the microphone approximately 6 to 8 inches

TABLE 5

A TYPICAL THERAPY SCHEDULE FOR A THREE-HOUR SESSION WITH OLDER CHILDREN

8:30-9:30	Body movements and implementation
9:30-9:45	Play break
9:45-10:00	Musical stimulations or beginning of reading readiness activities
10:00-11:00	Reading readiness activities and/or continued implementation; games for drill on auditory perception
11:00-11:30	Individual work -- remainder of class engaged in water painting, play-do or other similar type activities

from her mouth. This allowed the teacher to have both hands free for the use of body movements and any presentation to the children. Some children utilized bone vibrators (Suvag Vibra) in addition to the earphones, especially children with a severe problem in auditory perception.

In stimulating the children, the teacher always presented a consonant with a vowel. Table 6 displays the phonetic progression for teaching the consonants. The /pbm/ was the first consonant series to be taught. Then the teacher progressed to the /tdn/ series. She deviated from this order to satisfy the particular needs of the children in the group. As we progressed through the 1969-70 school year, there was less of a restriction to holding exactly to this order of teaching the sounds. Sounds were taught as they were needed for more understandable communication of the children. However, the philosophy in general was to begin with the low-frequency sounds, e.g., /pbm/, and teach progressively through the high-frequency sounds, e.g., /ʃ and s/. It should be noted that this phonetic progression is also the developmental order for normal-hearing children. In general the older children were able to perceive and associate words with the /pbm/, /tdnl/, and /h/ phonemes by the end of the 1969-70 school year. Of course, the younger children did not develop beyond the /pbm/ series.

The amount of progress in the phonetic continuum for each child affected the intelligibility scores as measured on the 1-9 scale, for intelligibility was evaluated by a list of 27 words that was representative of the phonetic continuum.

Discussion of the Subjects Within Each Group

The following is a discussion of the children according to the categories of hearing loss. These categories are: (1) moderate (40-59 dB HL); (2) severe (60-79 dB HL); and (3) profound (80 dB HL or greater). Table 7 displays "other" problems these children had in addition to their hearing loss. This table is divided into the Suvag B and Warren groups. Each subject will be discussed under the hearing loss categories and system of amplification. The discussion will point out the problems other than hearing loss which may or may not have influenced the performance level in the classroom, and especially in tests of perception. This section has been added to give the reader more insight into evaluation changes in the subjects. Subject number will be utilized as in Table 1. The reader should refer to Table 3 and the audiograms in Appendices A, B, and C for additional information.

With regard to hearing levels, only the Warren group included a child with a moderate loss (40-59 dB HL) in terms of two-frequency pure-tone average. This subject, $S_{37(W)}$, had obvious emotional problems, most likely related to her hearing loss. As she progressed in the development of auditory perception, there was a remarkably obvious trend toward the disappearance of the emotional problem. There was also an apparent relaxation on the part of the mother as her daughter overcame her anxieties.

In the severe hearing loss category (60-79 dB HL), $S_{31(W)}$, a Warren child, came from a family with low middle-class standards. This home environment also included an older deaf brother who was enrolled in a residential school and utilized manual communication. This probably affected $S_{31(W)}$'s communication skills.

TABLE 6

THE PHONETIC PROGRESSION FOR TEACHING SOUNDS IN THE ORDER OF LOW- TO HIGH-FREQUENCIES

pu		low-frequency sounds (1000-2000 Hz)
bu		
mu		
tu		
du		
nu		
lu		
ku		
gu		
fu		
vu		
hu		
wu		
whu		
thu	(ð)	middle-frequency sounds (2000-3000 Hz)
thu	(θ)	
ju		
shu		
chu		
yu		
ru		
zu		high-frequency sounds (4000 Hz)
su		

TABLE 7

A COMPARISON OF "OTHER" PROBLEMS IN ADDITION TO HEARING LOSS FOR SUVAG B AND WARREN CHILDREN

Categories of Hearing Loss*	SUVAG B GROUP		WARREN GROUP	
	Subject Number	Description	Subject Number	Description
Moderate 40-59 dB HL		(none)	S37(W)	severe emotional problem
Severe 60-79 dB HL	S22 (Sb)	behavior problem; characteristics of brain damage; visual problem; heart murmur	S31 (W)	deaf sibling; low middle class standards
	S39 (Sb)	deaf home environment		
	S41 (Sb)	severe emotional problem		
Profound 80 dB HL or greater	S25 (Sb)	low middle class standards; severe emotional problem	S24 (W)	low middle class standards; mild cerebral palsy, mostly affecting lower limbs; slow learning
	S27 (Sb)	split family		
	S28 (Sb)	low middle class standards	S26 (W)	behavior problem
	S29 (Sb)	low middle class standards; emotional problem; visual problem	S33 (W)	split family; low middle class standards
	S42 (Sb)	deaf home environment	S35 (W)	severe emotional problem
			S36 (W)	low middle class standards
			S 38 (W)	characteristics of brain damage; on medication

*Based on ISO two-frequency pure-tone average for the better ear.

The Suvag B group had three children in the severe hearing loss category. For two of the children, S22(Sb) and S41(Sb), one ear was consistently better than the other ear. This difference between the poorer and the better ear ranged from 5 dB to 50 dB at different frequencies. Their hearing losses were moderately severe and would seem to indicate a good prognosis for perception. Both of these children however, had additional problems which most likely affected their performance levels. S22(Sb) had a definite behavior problem; showed characteristics of brain damage, including hyperactivity, distractability, short attention span, and perseveration; possessed a visual problem (blindness in one eye as a result of congenital cataracts); and had a heart murmur. Likewise, S41(Sb) had serious emotional problems. The third child in this category, S39(Sb), was from a deaf home environment and was rated as being a slow learner.

The six children in the Warren group characterized by profound hearing loss (80 dB HL or greater) were observed to have these concomitant problems. S24(W) experienced a mild form of cerebral palsy, mainly affecting his lower limbs. In conjunction with the Verbo-tonal training program, he was also seen at a local rehabilitation center twice weekly for physical therapy. His overall learning rate was observed to be slow.

S26(W) had only one sibling (age 16) and it was quite apparent that this young child manipulated her home environment quite effectively, which created problems for the teacher in the classroom.

S33(W) was from a home of divorced parents, and the mother had recently remarried. There were no inside toilet facilities in the home, and consequently the child was not toilet-trained. Despite the fact that our program provided transportation, the mother many times did not bother to answer the door so her daughter could attend therapy. She was one child who showed very little auditory awareness.

S35(W) was a child with emotional problems. She was very passive and did not participate with other children in group activities. She was referred to a clinical psychologist for evaluation and therapy, if the latter was judged feasible. She was taken by her mother for evaluation, but was subsequently returned after only one therapy session. Her behavior was similar during the T7-T9 evaluation period.

S36(W) was a child on the borderline for being placed in the severe category. The teachers who worked with her did not feel that the I.Q. score of 62 obtained for her was representative of her functioning level. Rather, it was felt that she certainly evidenced average normal intelligence, if not higher. The prognosis for auditory perception was good. Financial difficulties, a new baby in the family, and a great distance to travel, all resulted in very poor attendance of this child at a very critical time in her development.

S38(W) was a child who was very difficult to test in any way. In spite of taking medication for hyperactivity, she still could not concentrate long enough and produce enough consistent responses to yield reliable test results. Other characteristics of brain damage which she manifested included perseveration, distractability, and a general state of tenseness and being "stimulus bound." From the start of therapy, her prognosis was "guarded." Her parents expected to see noticeable success within a week, or several weeks at the most. She was in and out of the program several times as her parents sought another, perhaps quicker, answer to her problems.

The Suvag B group of children with profound hearing loss (80 dB HL or greater) included two children, S25(Sb), S29(Sb), with emotional problems, whose home environments reflected low-middle class standards. In addition, S29(Sb) had an acute visual problem.

S27(Sb) was a child from a split family, but with no noticeable adjustment problems. She was one of the two children who showed the very least auditory awareness.

S28(Sb) was a child who was judged by the teachers to be the most well-adjusted child in the program (in spite of the fact that she represented the lowest income family). She had no apparent problems other than her hearing loss.

S42(Sb) was another child in the profound group who was on the border of having sufficient hearing in the better ear to be placed in the severe hearing loss group. S42(Sb) and S39(Sb) were related; both lived in deaf environments, although not in the same household.

The previous discussion included subjects from the Suvag B group and the Warren group. The following discussion will refer only to the Suvag A group. Table 8 includes information on the Suvag A group.

In the severe hearing loss group, S9(Sa) was a slight behavior problem, a situation possibly related to marital conflicts and the temporary disappearance and then return of the mother.

S11(Sa), also in this group, was from a home with lower middle class standards and displayed slow learning abilities in spite of his advantage in auditory potential.

In the profound hearing loss group, S8(Sa) was a child from a very disrupted home situation. Her parents were divorced, and the child lived with the maternal grandmother while the mother worked. She stayed up very late to keep her mother company and had irregular and very poor eating habits. In essence, she tried to continually go at an adult's pace in order to meet the demands of her environment. She was a slight behavior problem, perhaps reflecting the inconsistent limits imposed upon her by her mother and her grandmother.

The remainder of the subjects in the Suvag A group were in the profound hearing loss category. S14(Sa) was a child who displayed slow learning abilities, in addition to characteristics of brain damage, including distractability, short attention span, perseveration, and inadequate control of the peripheral speech mechanism - sluggish movements of a dysarthric nature. His general body state was one of excessive tension. He was a child who very likely would have an articulation problem even if his hearing had been normal.

TABLE 8

"OTHER" PROBLEMS IN ADDITION TO HEARING LOSS
FOR SUVAG A CHILDREN

Categories of Hearing Loss*	SUVAG A Children	
	Subject Number	Description
Moderate 40-59 dB HL		(none)
Severe 60-79 dB HL	S_9(Sa)	slight behavior problem
	S_{11}(Sa)	slow learning; lower middle class standards
Profound 80 dB HL or greater	S_8(Sa)	slight behavior problem
	S_{14}(Sa)	slow learning; characteristics of brain damage
	S_{15}(Sa)	characteristics of brain damage
	S_{16}(Sa)	behavior problem; slow learning
	S_{17}(Sa)	characteristics of brain damage
	S_{19}(Sa)	highly over-protected
	S_{20}(Sa)	severe emotional problem

*Based on ISO two-frequency pure-tone average for the better ear.

S_{15} (Sa) was a child who displayed possible brain damage in the form of lethargy throughout his body. His stance and gait were very awkward.

S_{16}(Sa) was a child who demonstrated slow learning abilities and was also a behavior problem. She had apparently learned how to manipulate her home environment to a certain degree.

S_{17}(Sa) was a highly-intelligent child but had discrete problems which hindered his progress in certain areas, specifically the development of speech rhythm. He also displayed gross motor problems as evidenced in his abnormal stance and gait, but evidenced no problems in dexterity.

The only apparent problem of S_{19}(Sa) other than his hearing loss was the extreme overprotection displayed by the parents, particularly the mother. As a consequence, he was shy, withdrawn, and would not even participate in free play with the other children for several months.

Severe emotional problems affected S_{20}(Sa), with no obvious cause for this behavior. He also was shy and withdrawn and it was several months before he would participate in free play activities with the other children.

CHAPTER III

INTELLIGIBILITY OF SPEECH SAMPLES

For this Interim Report, the criterion measures will be as follows: (1) the intelligibility of the speech samples as measured by the 1-9 scale, (2) the rate of vocalizations per minute, (3) the mean duration of the vocalizations, and (4) the mean fundamental frequency. The first criterion measure evaluates both the intelligibility of the speech samples or responses and the perception of the words or stimuli. The criterion measure pertains to the second and third aims of the original proposal which were identified in Chapter One in this report.

Chapter III will report the results of the first criterion measure and the other measures will be handled in subsequent chapters.

Testing Procedures

To evaluate auditory perception and speech production, a test list was constructed of 27 words that were common to preschol children and had phonemes that corresponded to the phonetic progression of teaching in the Verbo-tonal program. Table 9 displays the list. The reader is referred to Table 1 for the dates of the testing times. At testing time number four, words 28, 29, and 30 were added, whereas words 7, 19, and 24 were deleted to improve the validity of the test list. This test list was constructed with some degree of difficulty, the goal being to detect improvement over the testing times. A normal-hearing child would not perceive and produce all these words correctly until approximately five years of age.

As indicated earlier, speech samples were obtained by tape recording each child at 4-month intervals or three times each year. The same teacher (Mrs. Elsie French) tested each child in a sound-treated room. For each recording session, the teacher provided the oral stimulus or word and the child responded by attempting to imitate the stimulus. The 27 words were presented under four experimental conditions: (1) auditory clues *without* amplification, (2) visual and auditory clues *without* amplification, (3) auditory clues *with* amplification, and (4) visual and auditory clues *with* amplification. For condition 1 and 3, the teacher was seated directly behind the child and within eight inches of his ears. For conditions 2 and 4, the teacher was seated facing the child and within 12 inches of the child's ears. For conditions 1 and 2, the teacher attempted to speak at a normal conversational level (65-75 dB SPL) and the child wore no form of amplifcation, i.e., these were unaided conditions. For conditions 3 and 4, each child wore Koss earphones (model SP-3XC) and utilized the auditory training unit to which he was assigned. The output level of the auditory training unit was adjusted to the optimal level for each child. For these conditions with amplification (3 and 4), the teacher spoke into the appropriate microphone at a normal converstional level.

Each stimulus or word was presented two times to each child. After each presentation the teacher allowed sufficient time for the child to respond. The list of 27 words under each experimental condition was always presented in a randomized order. The teacher attempted to obtain measures that were typical of the child's performance in the classroom. If a child was not responding in a manner that was typical of his "average" classroom performance, the experimental condition was terminated and was attempted at another time. On the average, it was necessary to re-do some of the experimental conditions 20 percent of the time.

TABLE 9

(1) ORIGINAL TEST LIST OF 27 WORDS FOR EVALUATION OF AUDITORY PERCEPTION AND SPEECH PRODUCTION

1. pop
2. up
3. puppy
4. bee
5. baby
6. bye-bye
*7. moo-moo
8. me
9. mama
10. top
11. today
12. toe
13. daddy
14. duck
15. cookie
16. come
17. cat
18. good
*19. go
21. sit
22. ship
23. shoe
*24. chew
25. cheek
26. pillow
27. lamb
**28. meat
**29. bunny
**30. penny

(2) MODIFIED TEST LIST OF 15 WORDS USED FOR THE YOUNGER CHILDREN

3. puppy
4. bee
5. baby
6. bye-bye
9. mama
12. toe
13. daddy
15. cookie
16. come
20. soup
23. shoe
25. cheek
26. pillow
27. lamb
29. bunny

* Deleted at T_4

** Added at T_4

If each child were tested with 27 words under four conditions, he would have 108 samples per test time or 324 samples for the three test periods. However, some of the younger children were not capable of being tested with the entire 27 words and so a modified list of 15 words was utilized that was representative of the larger list. Table 9 identifies the modified list. This list was used only temporarily until a child could be tested with the larger list.

Randomizing and Judging of Samples

A total of 5,671 speech samples were randomized as a function of groups, subjects, testing times, testing conditions, and words, and then re-recorded on a master tape. Each speech sample on the master tape was preceeded by an identification number and included the teacher's stimulus and the child's response. A four-second silent interval which followed each response was utilized by the judges to record their responses.

Because of the large number of samples on the master tape, the listening times were divided into four-hour blocks with a 10-minute rest period at the end of each hour. Twelve to sixteen normal-hearing college students listened and judged during each four-hour session. The listeners were undergraduates or graduate students majoring in speech pathology and/or audiology. They received hourly payment for the listening time.

The listeners were instructed to judge each child's response in relation to the teacher's stimulus and then record their judgment on a 9-point scale. Table 10 displays a response sheet for recording 25 different judgments. Number 1 on this scale indicates that the response was similar to the stimulus, and number 9 indicates that the response was dissimilar to the stimulus. The numbers between 1 and 9 represent degrees of similarity and dissimilarity.

Data Analysis

The responses of the listeners were transferred to computer cards, with each computer card representing one word for a child under a particular experimental condition. Therefore, there was a computer card for each speech sample. These computer cards contained the judgment of each listener and all the necessary identification for processing the card.

An IBM computer program computed the mean 1-9 scale value and the standard deviation of the group of judges for each speech sample and then entered these values on the appropriate computer card. A second IBM computer program was utilized to compute the mean 1-9 scale value for each experimental condition for each subject under each testing time. For example, the mean of 27 words for S_8 (S_a), was 5.9 for condition number one for the testing time number nine. Each subject could have four means representing the four experimental conditions for each testing time and a total of twelve means for the entire year (three testing times). These means served as the criterion measure for an analysis of variance.

Because of either the lack of attendance or poor cooperation, it was not possible to obtain three testing times (T_7, T_8, and T_9) on all subjects. In fact, S_{24} (W) had only one testing time (T_9) even though

TABLE 10

RESPONSE SHEET

Similar **Dissimilar**

1. 1______2______3______4______5______6______7______8______9
2. 1______2______3______4______5______6______7______8______9
3. 1______2______3______4______5______6______7______8______9
4. 1______2______3______4______5______6______7______8______9
5. 1______2______3______4______5______6______7______8______9
6. 1______2______3______4______5______6______7______8______9
7. 1______2______3______4______5______6______7______8______9
8. 1______2______3______4______5______6______7______8______9
9. 1______2______3______4______5______6______7______8______9
10. 1______2______3______4______5______6______7______8______9
11. 1______2______3______4______5______6______7______8______9
12. 1______2______3______4______5______6______7______8______9
13. 1______2______3______4______5______6______7______8______9
14. 1______2______3______4______5______6______7______8______9
15. 1______2______3______4______5______6______7______8______9
16. 1______2______3______4______5______6______7______8______9
17. 1______2______3______4______5______6______7______8______9
18. 1______2______3______4______5______6______7______8______9
19. 1______2______3______4______5______6______7______8______9
20. 1______2______3______4______5______6______7______8______9
21. 1______2______3______4______5______6______7______8______9
22. 1______2______3______4______5______6______7______8______9
23. 1______2______3______4______5______6______7______8______9
24. 1______2______3______4______5______6______7______8______9
25. 1______2______3______4______5______6______7______8______9

he had 102 therapy hours throughout the year. Because he has an over-all mean of 8.5 for T_9, he probably would have been rated between 8.5 and 9.0 for either T_7 or T_8. As a result, a value of 8.5 was generated for T_7, so $S_{24}(W)$ could be included in the statistical analysis.

To maintain equal cells for the analyses of variance, the earliest testing time and the latest testing time for T_7, T_8, and T_9 for each subject were selected for the analysis. Thus, there were two testing times for each subject.

As discussed in Chapter II and displayed in Tables 1 and 2, 25 subjects were divided into three groups and identified as Suvag A (9 subjects), Suvag B (8 subjects), and the Warren group (8 subjects). These groups were compared in two ways: (1) Suvag B (8 subjects) vs the Warren group (8 subjects); and (2) Suvag A and B (17 subjects) vs the Warren group (8 subjects).

The other factor to consider was that of the four experimental conditions. For the statistical analyses, these four experimental conditions were divided into the following two factors: (1) amplification (A_1 = no amplification, and A_2 = amplification with earphones); and (2) conditions (C_1 = auditory clues only, and C_2 = both visual and auditory clues). In other words, the factor of amplification and the factor of condition each had two levels. The four experimental conditions were identified as A_1C_1, A_1C_2, A_2C_1, and A_2C_2.

Analyses by Groups

A four-factor analysis of variance (Winer, 1962) with repeated measures on three factors was utilized to analyze the 1-9 rating values. (In this Chapter, rating values will be referred to as "RV"). The repeated measures were on the factors of time, amplification, and condition, with each having two levels. The between-group factor also had two levels.

Table 11 displays the summary of the analysis of variance for the Suvag B group vs the Warren group. Table 12 displays the results of the analysis for the Suvag A and B group vs the Warren group. For both of these analyses, the between-group F-ratio was not significant.

The group means for three subgroups are as follows: (1) 6.39 for Suvag A, (2) 6.63 for Suvag B, and (3) 6.98 for Warren. The Suvag B group was 0.4 RV better than the Warren group. When Suvag A and B were combined, the group mean was 0.6 RV better than that of the Warren group.

Another method of comparing the group means is as a function of testing time. For the earliest testing time (T_E), the group mean was 7.2 for both Suvag B and Warren. As indicated earlier in Chapter II, we attempted to "match" the children in these two groups, and the 1-9 scores at the earliest testing time indicate that the attempt was successful. For the latest testing time (T_L), the group mean was 6.1 for Suvag B and 6.8 for Warren. Figure 12 displays the group means. The Suvag B group demonstrated 1.1 RV improvement, whereas the Warren group improved only 0.5 RV. If these groups continue to improve at the same rate, it appears that a significant difference may be detected in the second or third fiscal year of this research grant.

When the Suvag A and B groups were combined, the rate of improvement was 0.9 RV. The addition of the nine Suvag A children improved the overall group mean at the earliest testing time; however, it decreased the rate of improvement for the group. As indicated earlier, the Suvag A children were in the program prior to T_7. As a result, individual rates of improvement may not have been as great for the second or third year in the program.

TABLE 11

SUMMARY TABLE OF A 4-FACTOR ANALYSIS OF VARIANCE WITH TIME (T), AMPLIFICATION (A), AND CONDITIONS (C) AS REPEATED MEASURES, AND THE BETWEEN-GROUP FACTOR IDENTIFIED AS SUVAG B VS WARREN FOR ALL MEASURES AVAILABLE

SOURCE	SS	DF	MS	F
BETWEEN GROUPS				
Suvag B vs Warren	3.8	1	3.8	0.09
Sub. within Groups	589.4	14	42.1	---
WITHIN GROUPS				
Time (T)	18.5	1	18.5	12.37**
G.T.	3.2	1	3.2	2.14
T.A.	0.48	1	0.48	0.94
Amplification (A)	3.73	1	3.73	8.43**
G.A.	0.15	1	0.15	0.35
G.T.A.	0.09	1	0.09	0.18
Conditions (C)	1.5	1	1.5	6.42*
G.C.	0.13	1	0.13	0.57
T.C.	0.13	1	0.13	2.15
C.A.	0.14	1	0.14	1.27
G.T.C.	0.00	1	0.00	0.00
G.C.A.	0.03	1	0.03	0.3
T.C.A.	0.34	1	0.34	4.62*
G.T.C.A.	0.18	1	0.18	2.52

* = Significant at .05 level
** = Significant at .01 level

TABLE 12

SUMMARY TABLE OF A 4-FACTOR ANALYSIS OF VARIANCE WITH TIME (T), AMPLIFICATION (A), AND CONDITIONS (C) AS REPEATED MEASURES, AND THE BETWEEN-GROUP FACTOR IDENTIFIED AS SUVAG A AND B VS WARREN FOR ALL MEASURES AVAILABLE

SOURCE	SS	DF	MS	F
BETWEEN GROUPS				
Suvag A & B vs Warren	14.9	1	14.9	0.42
Sub. within Groups	808.63	23	35.16	---
WITHIN GROUPS				
Time (T)	26.1	1	26.1	17.24**
G. T.	1.8	1	1.8	1.21
T. A.	0.9	1	0.9	2.46
Amplification (A)	9.4	1	9.4	21.02**
G. A.	0.62	1	0.62	1.39
G. T. A.	0.1	1	0.1	1.14
Conditions (C)	6.57	1	6.57	14.04**
G. C.	0.16	1	0.16	0.33
T. C.	0.00	1	0.00	0.00
C. A.	0.1	1	0.1	1.39
G. T. C.	0.09	1	0.09	1.06
G. C. A.	0.00	1	0.00	0.06
T. C. A.	0.39	1	0.39	5.47*
G. T. C. A.	0.09	1	0.09	1.24

* = Significant at .05 level

** = Significant at .01 level

Mean Overall Ratings of Groups (Suvag B and Warren) As A Function of Time

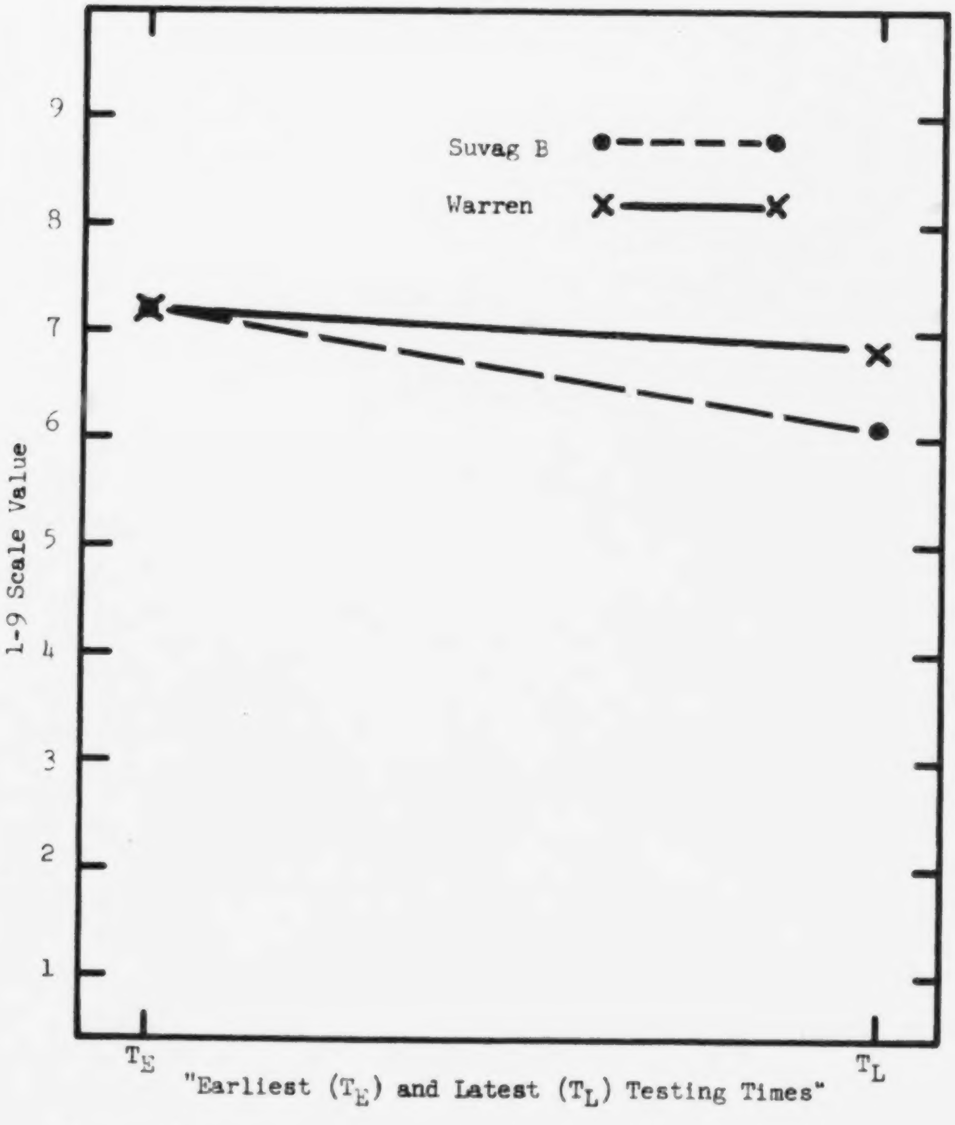


Figure 12.

The F-ratios for testing times were significant for both analyses, as indicated in Tables 11 and 12. This indicates a significant improvement in perception and speech production for the groups as a result of utilizing the Verbo-tonal Method.

The F-ratios for both amplification and conditions were significant for both analyses, as displayed in Tables 11 and 12. The factor of amplification for the first analysis was 6.6 for amplification with earphones (A_2) and 7.0 for no amplification (A_1). For the second analysis (Table 12), it was 6.4 for amplification and 6.8 for no amplification. In both analyses, the children performed better when using earphones.

The factor of conditions for the first analysis was 6.7 for visual and auditory clues (C_2) and 6.9 for auditory clues only (C_1). For the second analysis, it was 6.4 and 6.8, respectively. The children performed better when the teacher (tester) was in front of them, so that both visual and auditory clues were available.

Figure 13 displays the group means for Suvag B and Warren as a function of auditory clues with amplification (C_1A_2) and visual and auditory clues with amplification (C_2A_2). These graphs are displayed on the left and the right side of Figure 13, respectively. On the left side of Figure 13, the rate of improvement was 1.3 units for Suvag B, and it was 0.6 for Warren. On the right side of the graph, it was 1.0 RV for Suvag B and 0.6 RV for Warren. This demonstrates that the Suvag B group had a greater rate of improvement than the Warren group when amplification was used. This was especially true when only auditory clues were available.

Figure 14 displays the group means as a function of auditory clues without amplification (C_1A_1) and visual and auditory clues without amplification (C_2A_1). On the left side of the graph, Suvag B had a rate of improvement of 0.7 RV and Warren improved 0.2 RV. On the right side of the graph, Suvag B improved 1.2 RV, whereas Warren improved 0.4 RV. The rate of improvement of the Suvag B group was greater than that of the Warren group for both conditions. It is interesting that the Suvag B group (right side of Figure 14) was poorer at the earliest test time but was better than the Warren group at the latest test time.

As indicated earlier in this chapter, some of the younger children were not able to take the entire 27-word list for all four test conditions. As a result, a modified list of 15 words (See Table 9) was utilized until these children were capable of the longer test list. To evaluate the effect of the number of words, the data were analyzed according to three data sets. These data sets were as follows: (1) all available words for each subject, (2) the same number of words for the earliest and latest test times for each subject, and (3) the same number of words for all subjects for both test times. In other words, data set number three used only the same 15 words (modified list) for all subjects. Data set number two used 15 words for some subjects and 27 words for other subjects. Data set number one used all the words that were available for each subject.

In Table 13, the first three columns of F-ratios are identified as F_1, F_2 and F_3 and correspond to data sets one, two and three, respectively. Column one in this table includes the same F-ratios that were viewed in Table 11 for the Suvag B analysis. As can be observed, the F-ratios for the three columns are similar, which indicates that the number of words utilized did not noticeably alter the level of significance.

Mean Ratings of Groups (Suvag B and Warren)
As A Function of Auditory Clues With Amplification,
Visual-Auditory Clues With Amplification, and Time

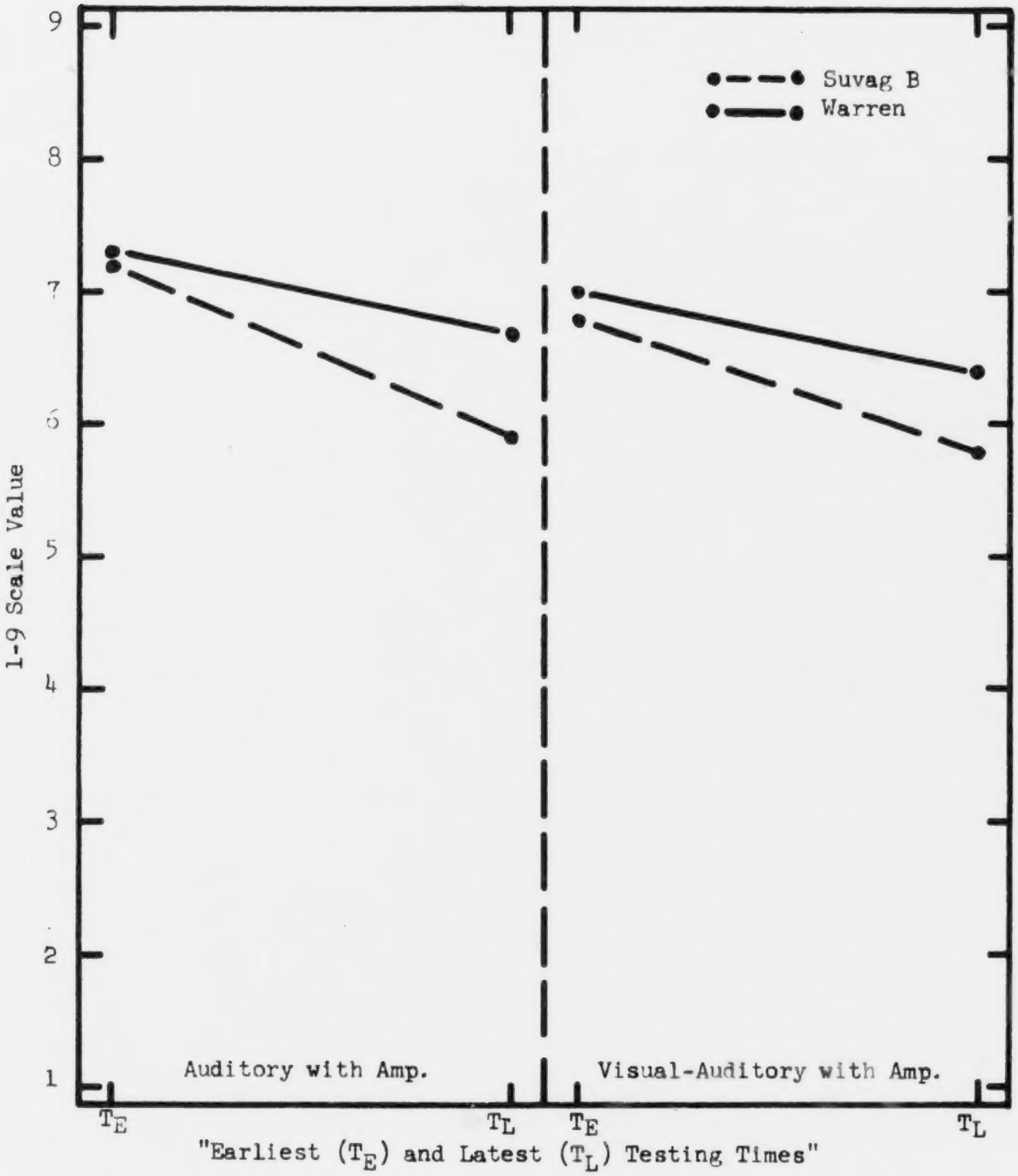


Figure 13.

Mean Ratings of Groups (Suvag B and Warren)
As A Function of Auditory Clues,
Visual-Auditory Clues and Time

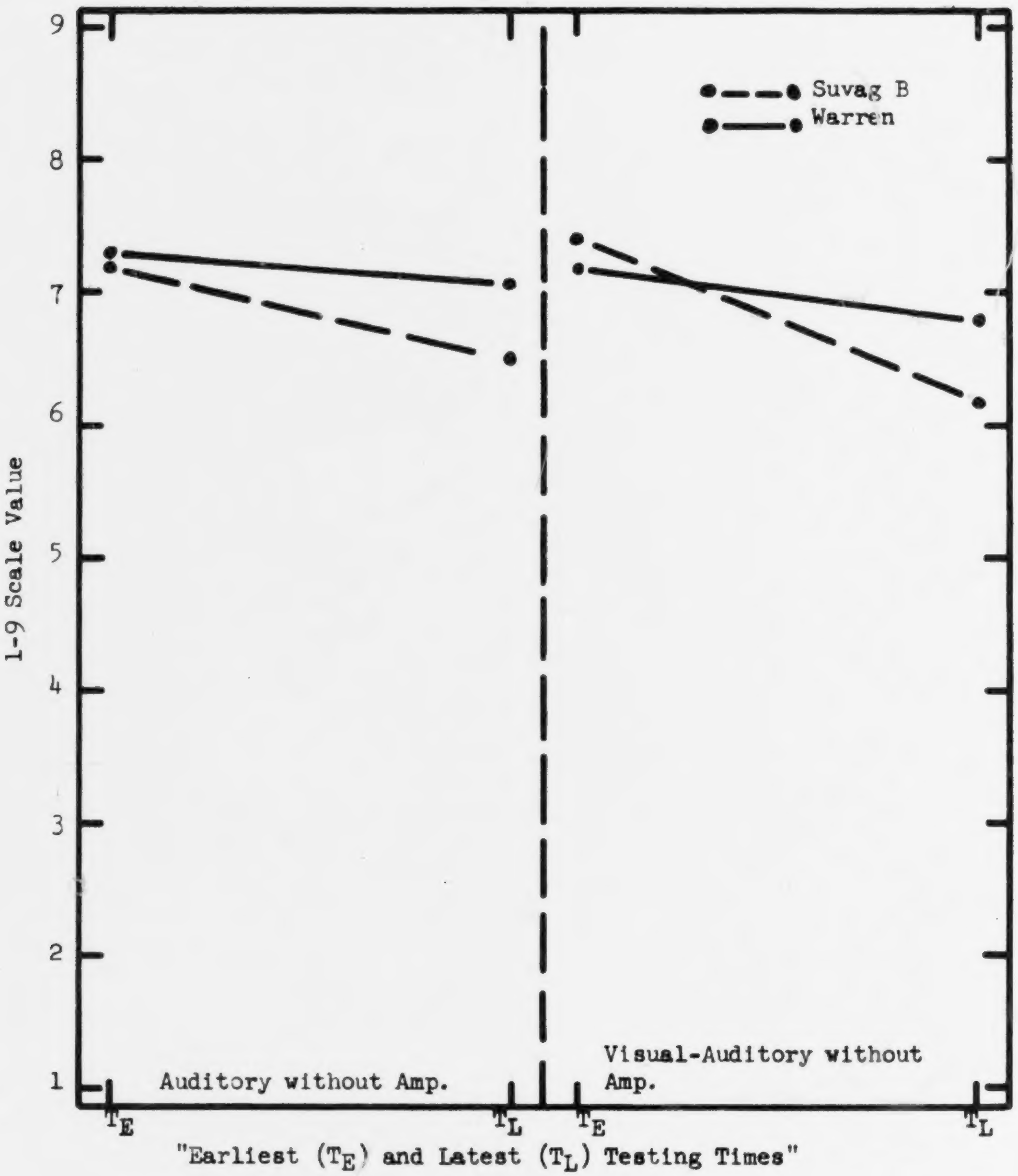


Figure 14.

TABLE 13

A COMPARISON OF F-RATIOS ACCORDING TO FOUR WAYS OF PROCESSING THE DATA FOR SUVAG B VS WARREN

	F_1	F_2	F_3	$F_{T_1-T_2}$
BETWEEN GROUPS				
Suvag B vs Warren	0.09	0.1	0.09	2.15
Sub. within Groups				
WITHIN GROUPS				
Time (T)	12.37**	11.84*	11.81*	
G.T.	2.14	2.3	2.3	
T.A.	0.94	1.07	0.61	
Amplification (A)	8.43**	9.85**	10.4**	0.94
G.A.	0.35	0.66	0.6	0.20
G.T.A.	0.18	0.1	0.01	
Conditions (C)	6.42*	5.83*	6.44*	2.15
G.C.	0.57	0.64	0.8	0.00
T.C.	2.15	0.67	0.4	
C.A.	1.27	0.51	0.03	4.60*
G.T.C.	0.00	0.00	0.00	
G.C.A.	0.3	0.24	0.33	2.52
T.C.A.	4.62*	6.95*	7.43*	
G.T.C.A.	2.52	3.22	1.2	

* = Significant at .05 level
** = Significant at .01 level

KEY:

F_1 = all measures
F_2 = same number of measures within each subject
F_3 = same measures for all subjects
$F_{T_1-T_2}$ = the latest measures subtracted from the earliest measures for each subject

The fourth column in Table 13 displays the F-ratios for T_1 minus T_2. In this case, the scores for the latest test time were subtracted from the scores for the earliest test time for all subjects in the Suvag B and the Warren groups. These difference scores were utilized for the analyses of variance. As can be observed, the between-group F-ratio was 2.15 and reached a probability level of 0.16. If these difference scores were analyzed only for the condition of amplification, the F-ratio might reach the .05 level of significance.

Table 14 includes the difference scores for the subjects in the Suvag A, Suvag B, and Warren groups. The conditions were identified as C1A1, C2A1, C1A2, and C2A2. The sum and mean difference for each subject and each condition is computed.

Intelligibility of the 1-9 Scale

The 1-9 rating scale has been utilized to evaluate the intelligibility of the speech samples obtained from the children. In order to determine at what point on the scale the samples become intelligible, the following evaluation was undertaken. Two-hundred and fifty samples that had been judged on the 1-9 scale were selected on the basis of having an equal number from each portion of the scale. These responses of the children were re-recorded and judged by a group of normal-hearing college students who were unfamiliar with the type of samples that were being judged. The listeners wrote the words they thought the children had said. The judgements of these listeners were scored according to intelligibility. In order for a word to be intelligible, it had to be perceived correctly by the judges and also had to be a correct response by the child in relation to the stimulus. In other words, an intelligible response by a child was both intelligible and correct.

Figure 15 displays the median points of intelligibility for words with a rating value (RV) between one and four. An interpolative line has been constructed between the median points. As can be observed, the intelligibility decreases as the RV decreases from one to four. For responses with an RV of one, the intelligibility was 85 percent. This relatively-low percentage is understandable because each response was one word taken out of context and recorded on a tape recorder. If these responses were inserted in sentences, they would be 100 percent intelligible. As a result of this evaluation, the following intelligibility levels were assigned for the 1-9 scale: RV one equals 85 percent, RV two equals 32 percent, RV three equals 10 percent, RV four equals 9 percent, RV five equals 6 percent, RV six equals 4 percent, RV seven equals 2 percent, RV eight and nine equal 0 percent.

As can be observed, intelligibility is not linear across the 1-9 scale. From an RV of 9 to an RV of 5 on the scale, intelligibility increases only to 6 percent. This probably signifies that some basic changes in the intonation, rhythm and duration of the speech signal have occurred which make the response more like the stimulus, but which do not have a great effect upon its intelligibility. These basic changes are necessary before the speech sample can reach a level of understandability. From an RV of 5 to an RV of 1 on the scale, the intelligibility increases from 6 to 85 percent. A child who achieves an RV of at least two on the scale is probably intelligible in simple general conversation. These intelligibility values will be plotted on the right side of the following 1-9 scale graphs. Thereby, the reader will have some idea of the intelligibility of the individual words for these children.

The next three sections will discuss individual subject graphs according to the following order: the Suvag A, the Suvag B, and the Warren group. The left ordinate of each graph will identify the 1-9 scale values, the right or-

TABLE 14

EARLIEST TESTING TIME MINUS THE LAST TESTING TIME (DIFFERENCE SCORES) FOR EACH SUBJECT AMPLICATION (A_1 AND A_2) AND CONDITIONS (C_1 AND C_2)

Subjects	C_1A_1	C_2A_1	C_1A_2	C_2A_2	Sum Diff	Mean Diff
SUVAG A						
S_8	0.1	0.2	1.7	0.2	2.2	0.6
S_9	2.8	1.7	2.4	1.9	8.8	2.2
S_{11}	1.4	1.6	1.7	1.2	5.9	1.5
S_{14}	0.7	0.8	1.3	0.5	3.3	0.8
S_{15}	0.4	0.2	0.6	0.0	1.2	0.3
S_{16}	-0.1	0.6	0.6	1.1	2.2	0.6
S_{17}	0.6	0.4	1.6	1.2	3.8	1.0
S_1[illegible]	0.1	0.2	-0.6	0.2	-0.1	-0.0
S_{20}	-0.9	-1.3	---	-0.7	-2.9	-1.0
Sum	5.1	4.4	9.3	5.6	24.4	
Mean	0.6	0.5	1.2	0.6	0.7	
SUVAG B						
S_{22}	2.8	2.2	4.0	3.6	12.6	3.2
S_{25}	0.0	0.0	2.3	2.3	4.6	1.2
S_{27}	-0.6	0.4	0.0	-0.3	-0.5	-0.1
S_{28}	0.9	2.2	1.7	1.8	6.6	1.7
S_{29}	0.2	1.1	0.6	-0.1	1.8	0.5
S_{39}	0.0	0.3	0.0	0.1	0.4	0.1
S_{41}	0.4	0.5	0.3	0.5	1.7	0.4
S_{42}	2.4	3.3	1.1	0.4	7.2	1.8
Sum	6.1	10.0	10.0	8.3	34.4	
Mean	0.8	1.3	1.3	1.0	1.1	
WARREN						
S_{24}	---	---	---	---	---	---
S_{26}	0.6	0.7	0.5	1.3	3.1	0.8
S_{31}	0.5	-0.2	0.7	0.1	1.1	0.3
S_{33}	0.0	0.2	0.9	1.3	2.4	0.6
S_{35}	0.3	0.1	2.3	1.9	4.6	1.2
S_{36}	0.5	1.7	---	0.6	2.8	0.93
S_{37}	0.0	0.1	0.0	0.4	0.5	0.1
S_{38}	-0.6	0.1	-0.6	-0.4	-1.5	-0.4
Sum	1.3	2.7	3.8	5.2	13.0	
Mean	0.2	0.4	0.6	0.7	0.5	

KEY:

Minus (-) = the latest score was poorer (larger) than the earlier score for that experimental condition

--- = both the earliest and latest scores were not available

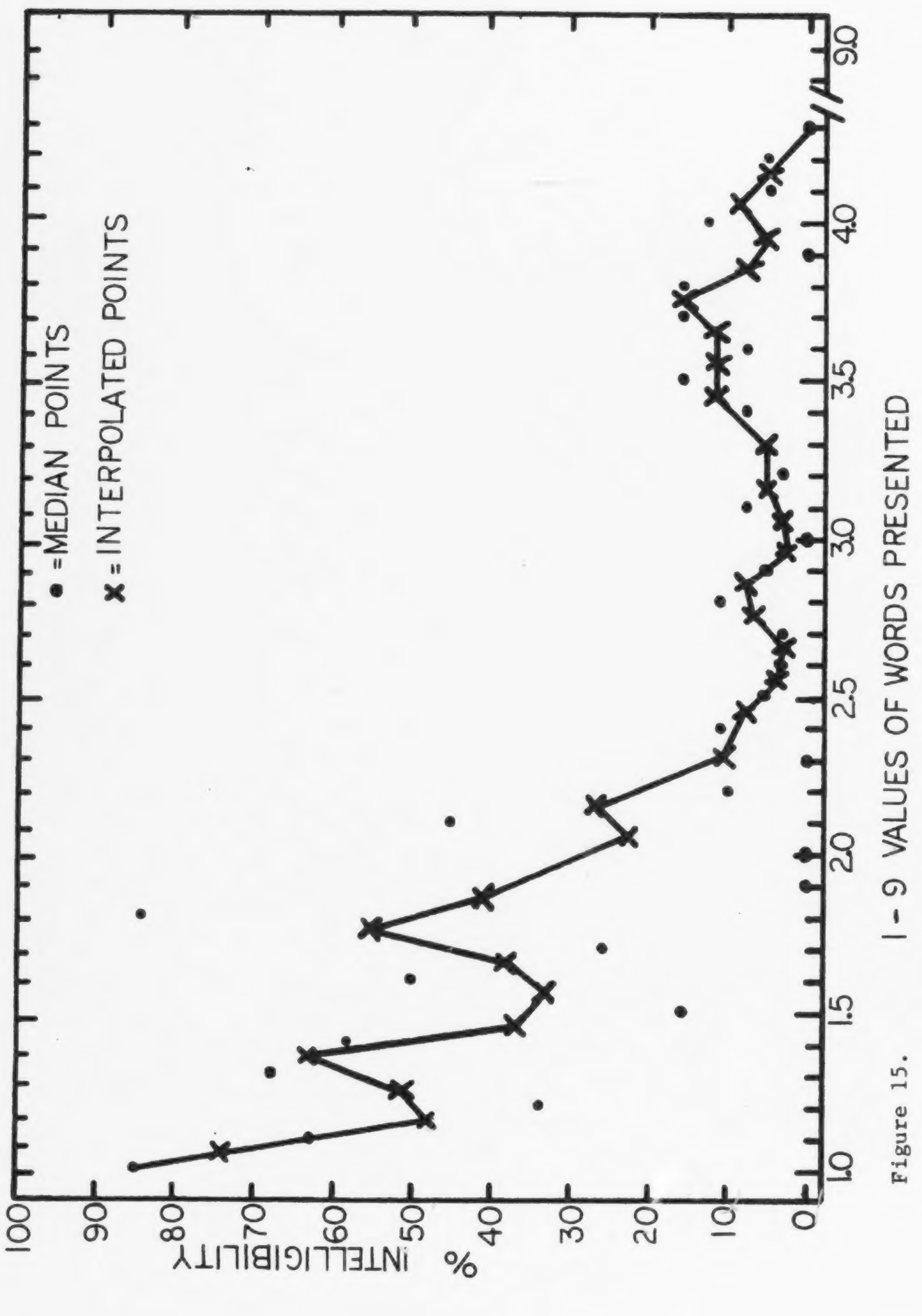

● = MEDIAN POINTS
✖ = INTERPOLATED POINTS
% INTELLIGIBILITY
100
90
80
70
60
50
40
30
20
10
0
1.0
1.5
2.0
2.5
3.0
3.5
4.0
9.0
1 - 9 VALUES OF WORDS PRESENTED

Figure 15.

dinate will identify the percentage of intelligibility, and the abcissa will identify the testing times. The reader is referred to Table in Chapter I for an identification of the dates of the testing times. Appendices A, B and C include the audiograms of these children. It should be remembered that the statistical analyses in the previous section utilized the data from T_7, T_8, and T_9.

Suvag A, Individual Graphs

Figures 16 through 24 display the individual graphs of the nine subjects in the Suvag A group. Each figure will be referred to and discussed in order to gain some insight into improvement of the children as a function of therapy time.

Figure 16 displays the mean for S_8. The solid line connects the points for the conditions with amplification and the broken line connects the points for the conditions without amplification. The dot represents the condition with auditory clues only and the X represents the conditions with visual and auditory clues. As can be observed, S_8 has mean values dating from T_1 through T_9 which covers a three-year period. On the abscissa, the reader should observe the arrow between T_6 and T_7 which indicates the implementing of the experimental design for the Research Grant. From T_1 through T_3 only the unaided conditions were utilized which are represented by the broken line. As can be observed, S_8 improves from an early 1-9 value of approximately eight to a value of approximately five by the T_9 testing times. This subject does noticeably better with amplification (solid line). Although this child is profoundly deaf (91 dB in the better ear), she perceives exceptionally well with auditory clues only and amplification (solid line with the dot). This is especially noticeable at the T_9 testing time.

Figure 17 displays the mean for S_9. As can be observed, S_9 improves five points on the scale value from T_1 through T_6. This is a very impressive amount of improvement over a two-year period. This subject has a 61 dB hearing loss. By T_9 she has reached a scale value of approximately two and perceives equally well under all four conditions. This is the most impressive graph of any that will be displayed in this section.

Figure 18 displays the values for S_{11}. There is approximately four point improvement from T_1 through T_6. From T_5 through T_9 the conditions with amplification (solid line) are considerably better. His hearing loss is 60 dB in the better ear and 91 dB in the poorer ear. He comes from a lower-middle class family who do not provide and demand good speech. Although S_{11} is not extremely motivated to communicate he is quite capable of being very effective in oral communication.

Figure 19 displays the mean for S_{14}. As can be observed, there is a great separation between the four conditions for this child. His best condition is visual and auditory clues with amplification (solid line with X). Visual clues for this child are extremely important. S_{14}'s auditory perception is better than his speech production. As a result, his 1-9 rating values are lower than his performance in the classroom would indicate.

Figure 20 displays the mean of S_{15}. He displayed very little improvement from T_4 through T_9. His hearing loss is 93 dB or greater in the speech frequencies; however, the average of 125 and 250 Hz is 50 dB in the better ear. Based on the better hearing at lower frequencies, one would assume the prognosis would be good for this child. However, he had a noticeable lack of body tension

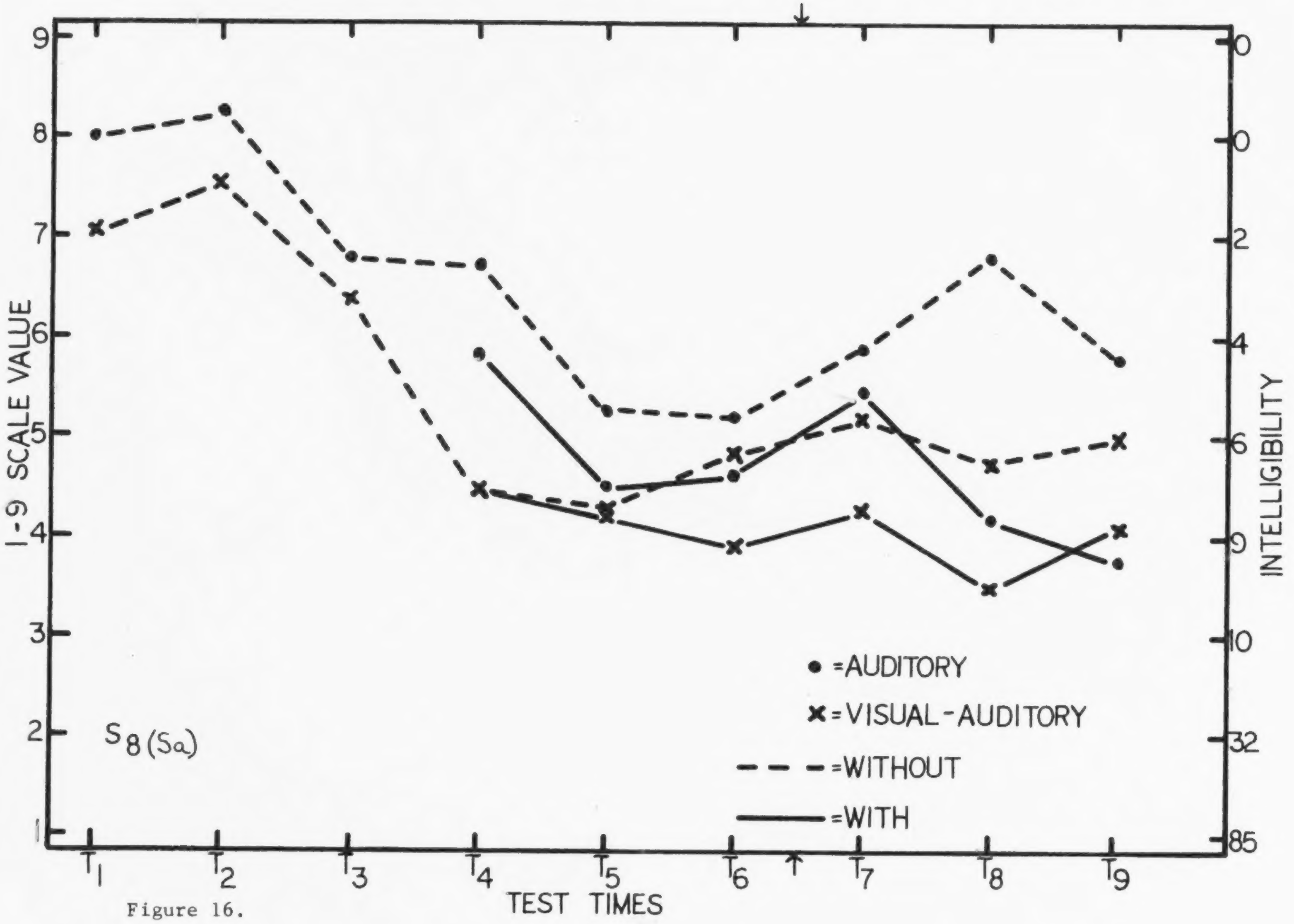

9
8
7
6
5
4
3
2
1
1-9 SCALE VALUE
0
0
2
4
6
9
9
10
32
85
INTELLIGIBILITY
T1
T2
T3
T4
T5
T6
T7
T8
T9
TEST TIMES
S8 (Sa)
● =AUDITORY
✖=VISUAL-AUDITORY
– – – =WITHOUT
——— =WITH

Figure 16.

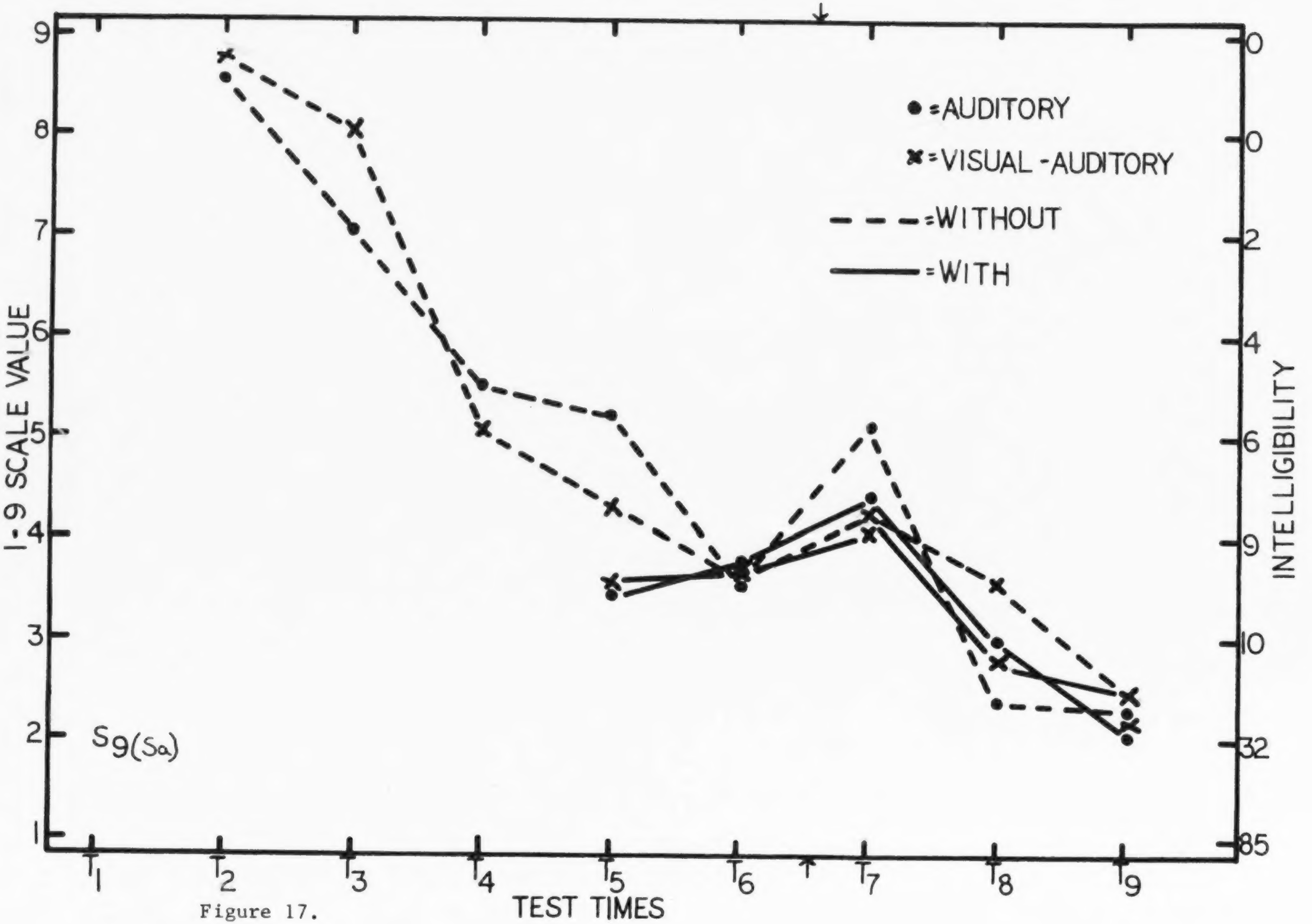

Sg(Sa)
●=AUDITORY
✖=VISUAL-AUDITORY
- - - =WITHOUT
——=WITH
I-9 SCALE VALUE
1
2
3
4
5
6
7
8
9
INTELLIGIBILITY
0
0
2
4
6
9
9
10
32
85
TEST TIMES
T_1
T_2
T_3
T_4
T_5
T_6
T_7
T_8
T_9

Figure 17.

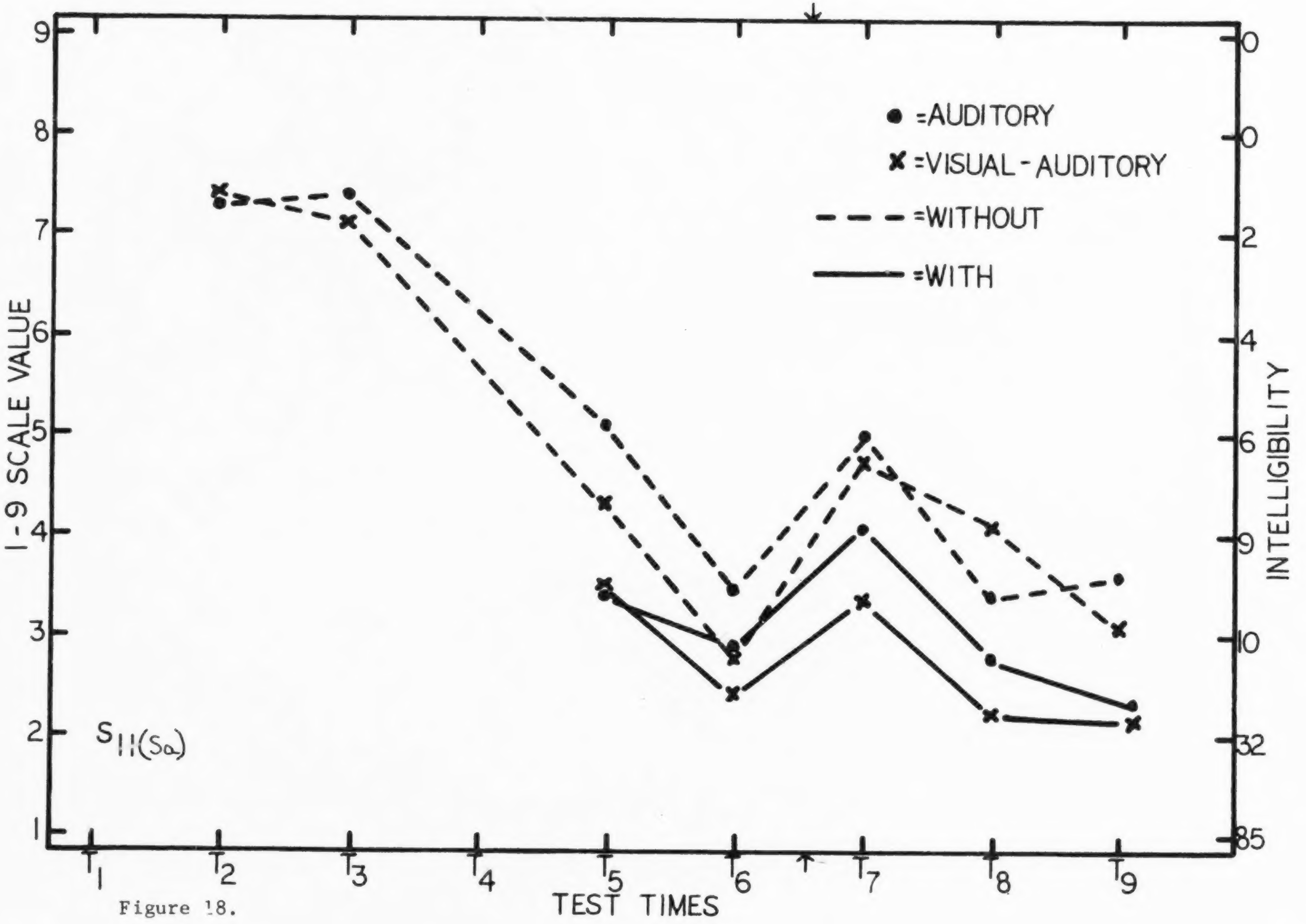

● =AUDITORY
✖ =VISUAL - AUDITORY
- - - =WITHOUT
—— =WITH
S11(Sa)
1-9 SCALE VALUE
9
8
7
6
5
4
3
2
1
INTELLIGIBILITY
0
0
2
4
6
9
10
32
85
T1
T2
T3
T4
T5
T6
T7
T8
T9
TEST TIMES

Figure 18.

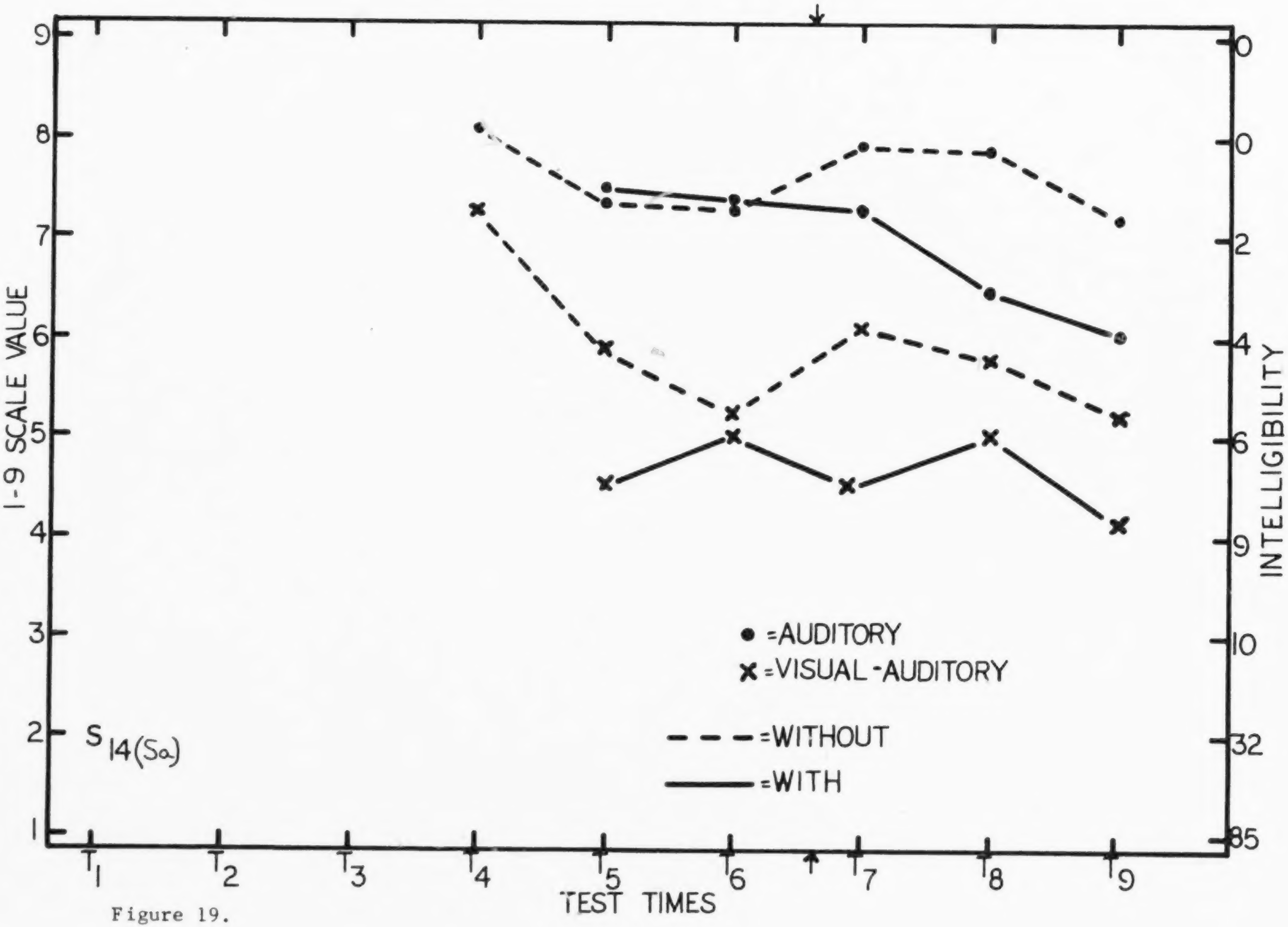

S 14(Sa)
1-9 SCALE VALUE
1
2
3
4
5
6
7
8
9
INTELLIGIBILITY
0
0
2
4
6
9
10
32
85
T1
T2
T3
T4
T5
T6
T7
T8
T9
TEST TIMES
● =AUDITORY
X =VISUAL-AUDITORY
- - - =WITHOUT
—— =WITH

Figure 19.

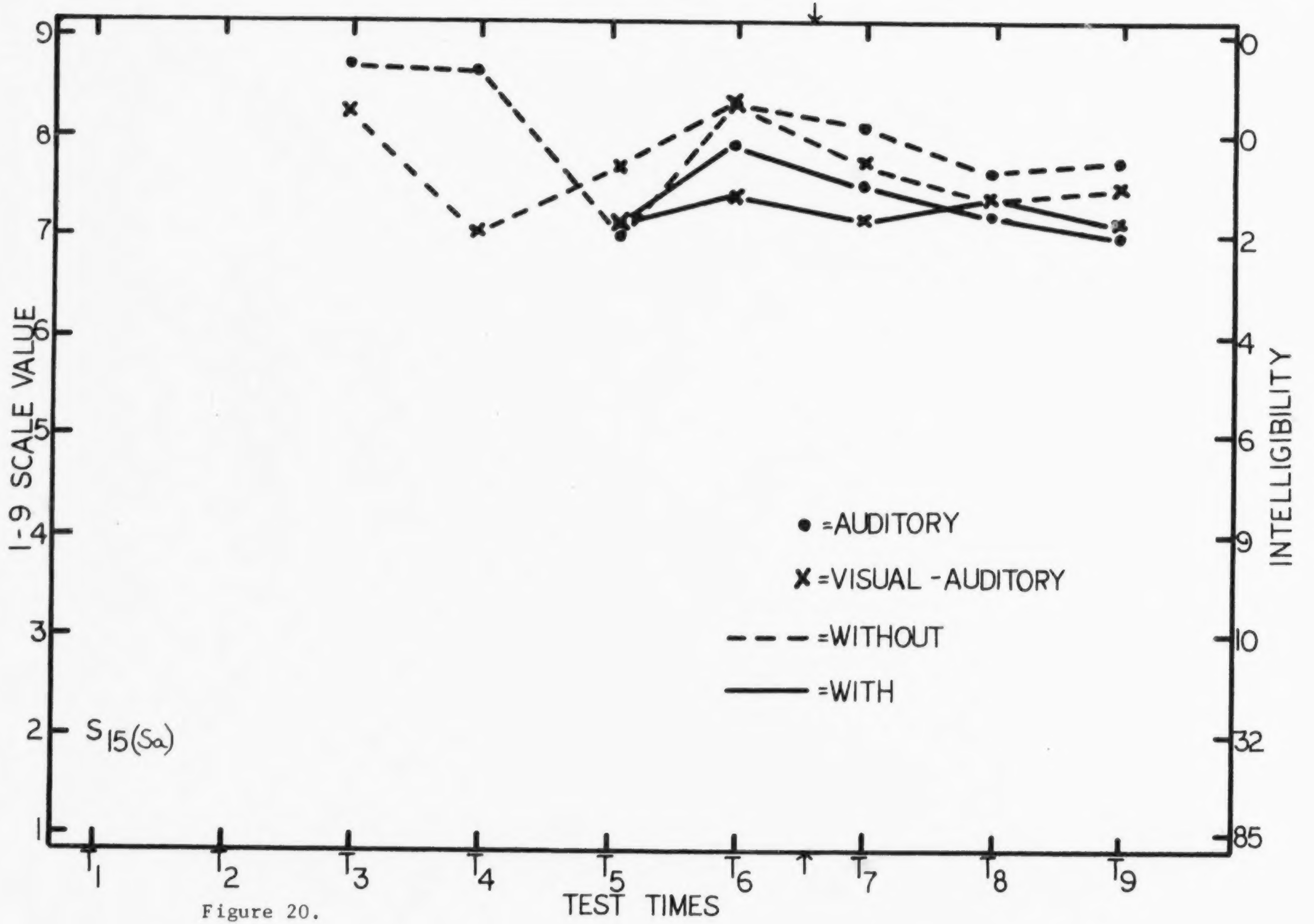

1-9 SCALE VALUE
9
8
7
6
5
4
3
2
1
INTELLIGIBILITY
0
0
2
4
6
9
10
32
85
TEST TIMES
T_1
T_2
T_3
T_4
T_5
T_6
T_7
T_8
T_9
$S_{15}(Sa)$
● =AUDITORY
X =VISUAL - AUDITORY
- - - =WITHOUT
—— =WITH

Figure 20.

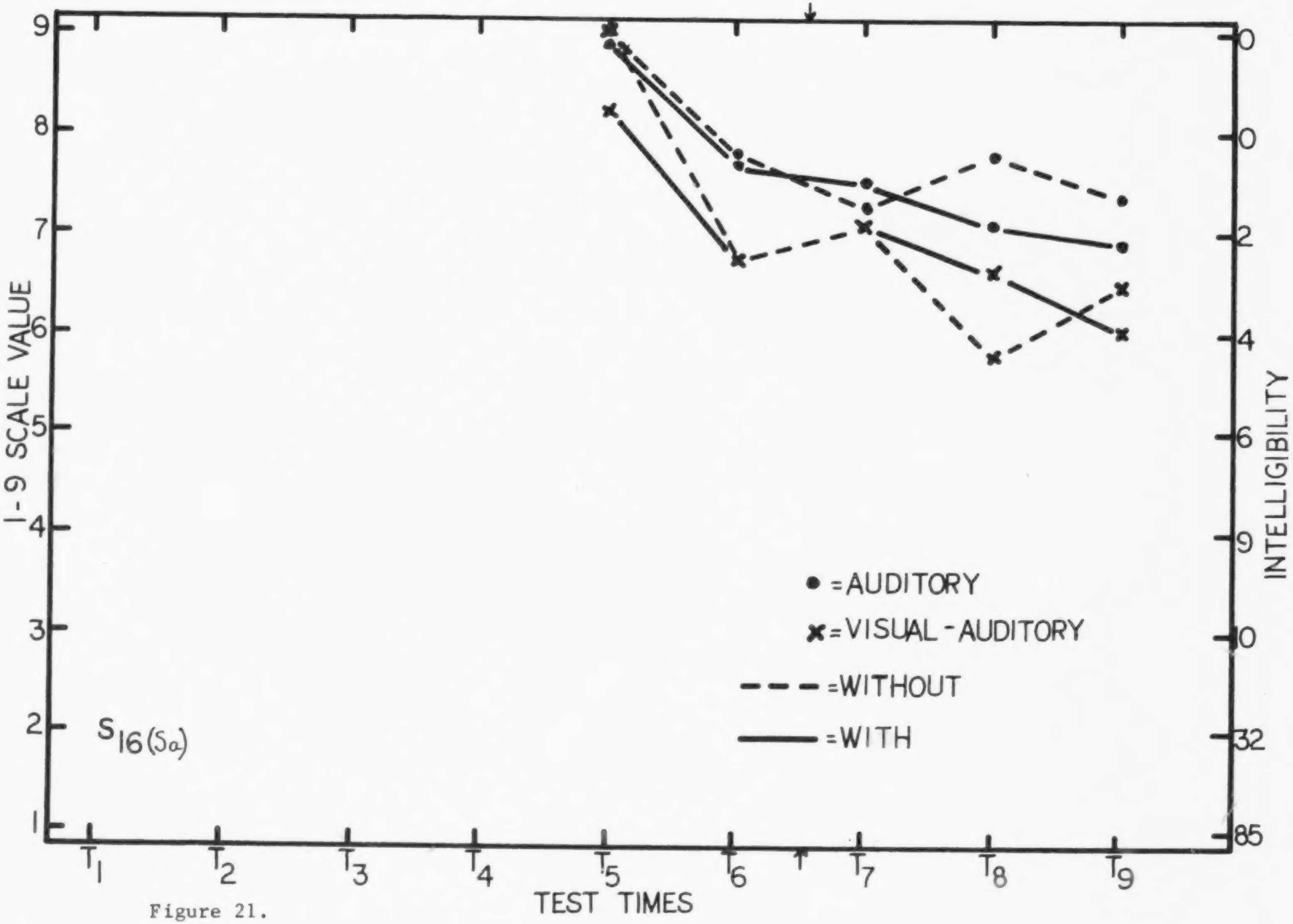

1-9 SCALE VALUE
9
8
7
6
5
4
3
2
1
INTELLIGIBILITY
0
0
2
4
6
9
10
32
85
T1
T2
T3
T4
T5
T6
T7
T8
T9
TEST TIMES
S16(Sa)
● = AUDITORY
✖ = VISUAL - AUDITORY
- - - =WITHOUT
—— =WITH

Figure 21.

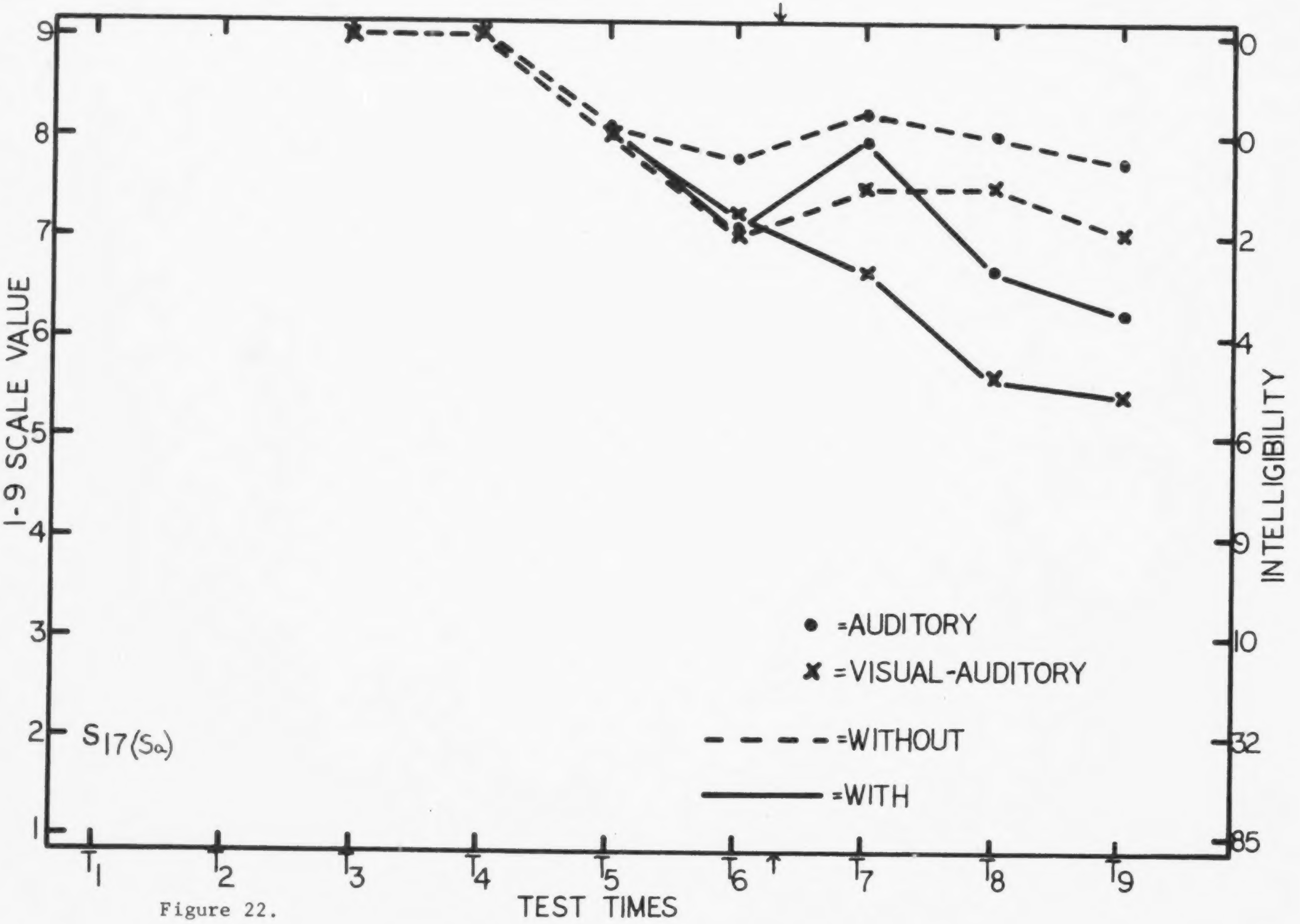

1-9 SCALE VALUE
9
8
7
6
5
4
3
2
1
INTELLIGIBILITY
0
0
2
4
6
9
10
32
85
TEST TIMES
T_1
T_2
T_3
T_4
T_5
T_6
T_7
T_8
T_9
S_{17}(Sa)
● =AUDITORY
✖ =VISUAL-AUDITORY
- - - - =WITHOUT
—— =WITH

Figure 22.

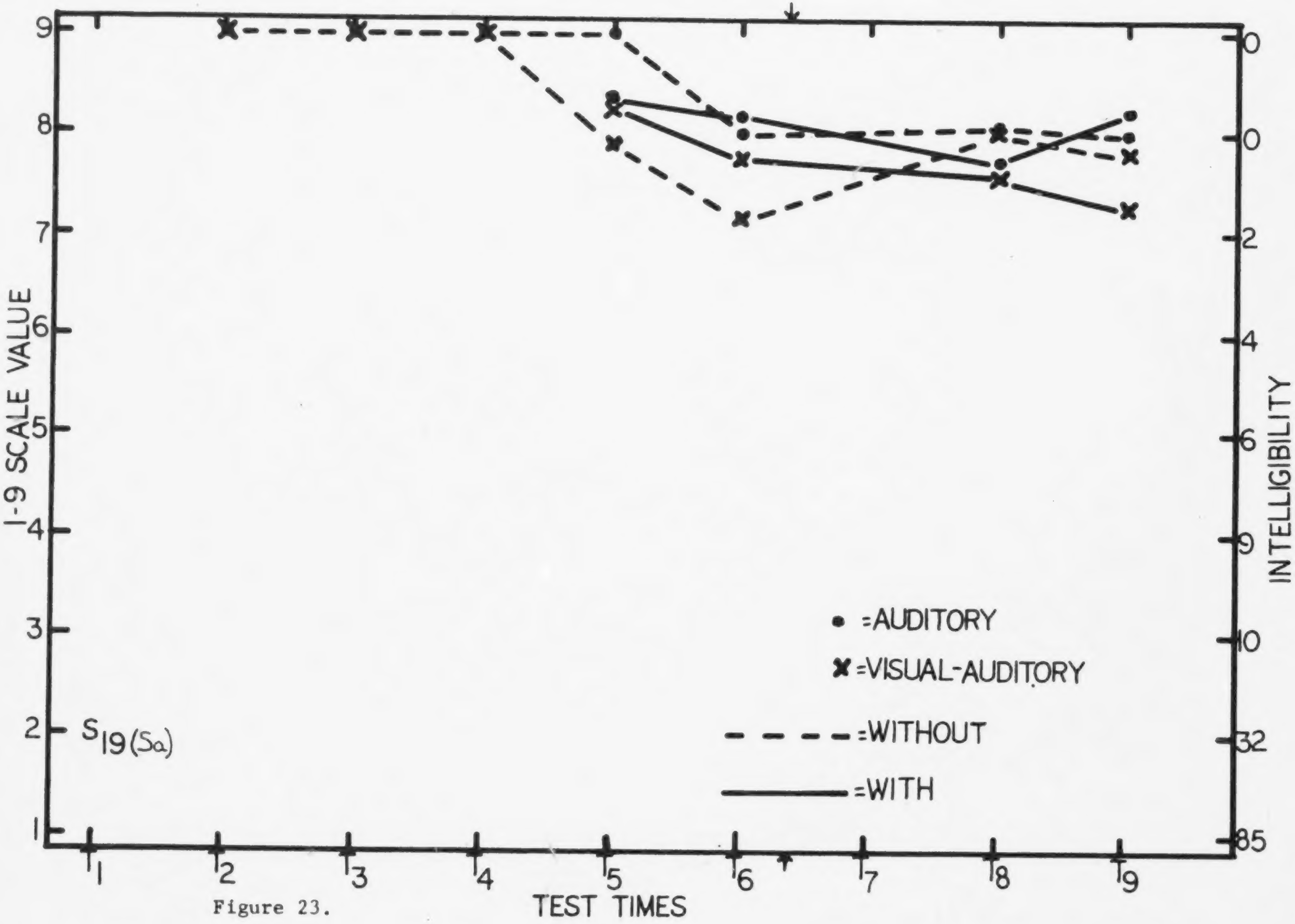

9
8
7
6
5
4
3
2
1
1-9 SCALE VALUE
S_{19}(Sa)
1
2
3
4
5
6
7
8
9
TEST TIMES
0
0
2
4
6
9
10
32
85
INTELLIGIBILITY
● =AUDITORY
✖ =VISUAL-AUDITORY
- - - - =WITHOUT
——— =WITH

Figure 23.

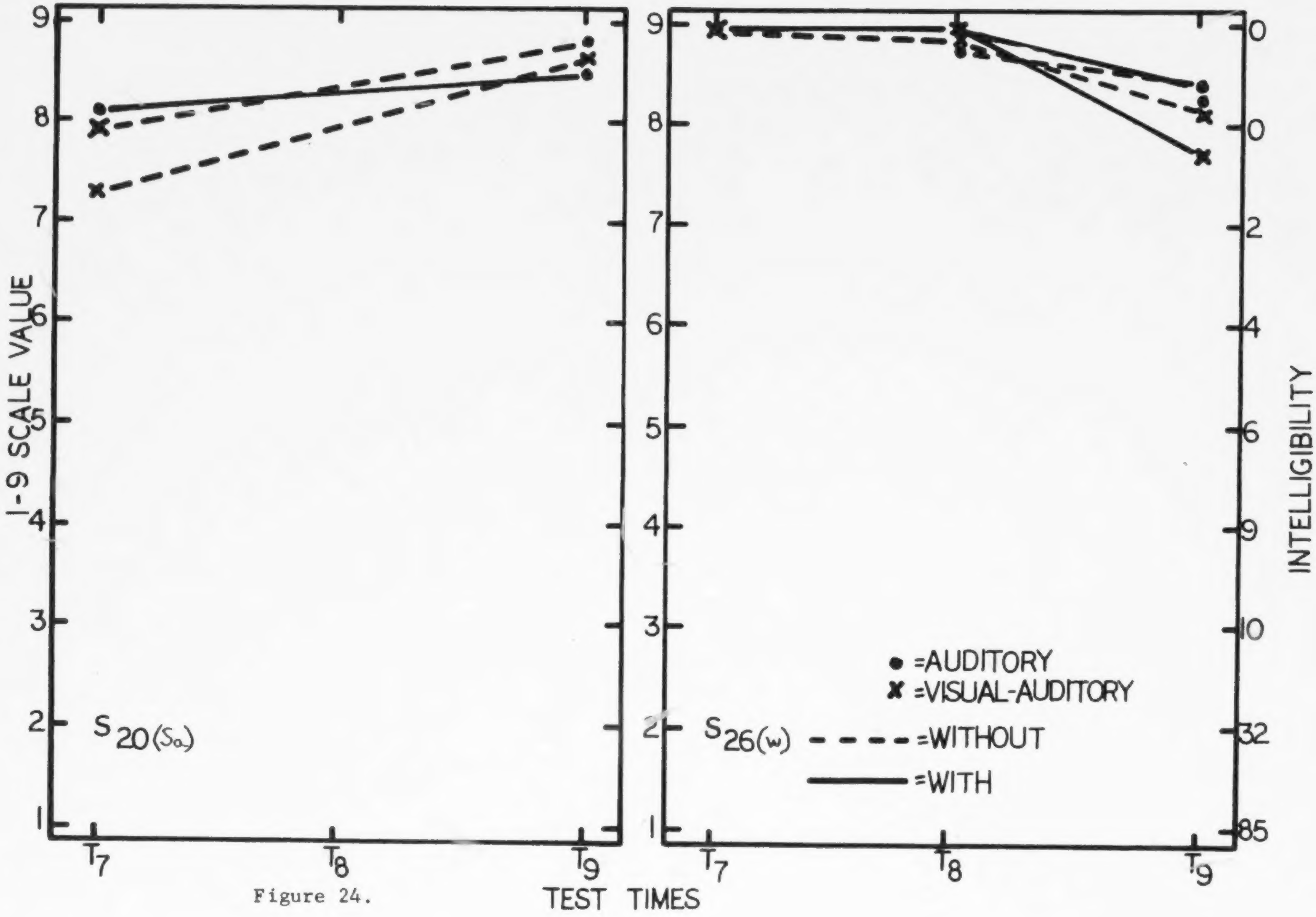

1-9 SCALE VALUE
9
8
7
6
5
4
3
2
1
$S_{20(S_a)}$
T_7
T_8
T_9
TEST TIMES
$S_{26(w)}$
● =AUDITORY
✗ =VISUAL-AUDITORY
- - - - =WITHOUT
—— =WITH
INTELLIGIBILITY
0
0
2
4
6
9
10
32
85

Figure 24.

and was very lethargic in his movements. He appeared to have "other" problems and seemed to be limited in his ability to improve in auditory perception. If this had continued in the program, he probably would not have improved much beyond this point.

Figure 21 displays the mean for S16. For this subject, visual and auditory clues (x), appeared to provide the best condition for perception.

Figure 22 displays the mean for S17. As the child progressed from T3 through T9 there is a noticeable separation in the conditions. At T9 he does noticeably better for the conditions with amplification (solid line). He also performs better when visual and auditory clues are available.

Figure 23 displays the mean for S19. As can be observed, S19 displayed very little improvement from T2 through T9. In addition to a severe hearing loss, this subject appeared to have some atypical behavior that may be indicative of other perceptual problems.

Figure 24 displays the mean for S20 and S26. Only the mean of S20 will be disucssed here. S20 was very difficult to test and the responses are probably unreliable. In fact, the scores are poorer for T9 than for T7. This subject dropped out of the preschool program before T9, and was requested to return for the T9 testing time. Both S19 and S20 were referred to the residential school for the deaf one year early because they were not capable of developing auditory perception in our program. It was the staff's opinion that both of these children could profit more from visual communication. The discussion for S26 will be included under the section for the Warren group.

Suvag B, Individual Graphs

Figures 25 through 28 include individual graphs for the eight subjects in the Suvag B group. Discussion will be similar to that in the previous section.

Figure 25 displays the mean for S22 and S25. S22(left side of the graph) demonstrates a marked improvement from T7 through T9. She performs noticeably better with amplification. The hearing loss is 76 dB in the better ear.

S25 demonstrates a marked improvement for the condition with amplification from T7 through T8. On the other hand, there is no improvement for conditions without amplification. The hearing loss is 90 dB.

Figure 26 displays the mean for S27 and S28. S28 (right side) showed a greater degree of improvement than S27. Both subjects have a severe hearing loss, but S28 has continued to improve in auditory perception and the prognosis is good for continued improvement.

Figure 27 displays the mean for S29 and S39. S29 shows some degree of improvement, but is not consistent from one testing time to another.

S39 demonstrates little or no improvement from T8 to T9, but he was able to perform at the level of two RV. This child has a 63 dB hearing loss and his mother is deaf. He was referred to our program because he was diagnosed as mentally retarded which he is not. After one year in our program he was placed back into a hard-of-hearing classroom in the public school and has performed very well.

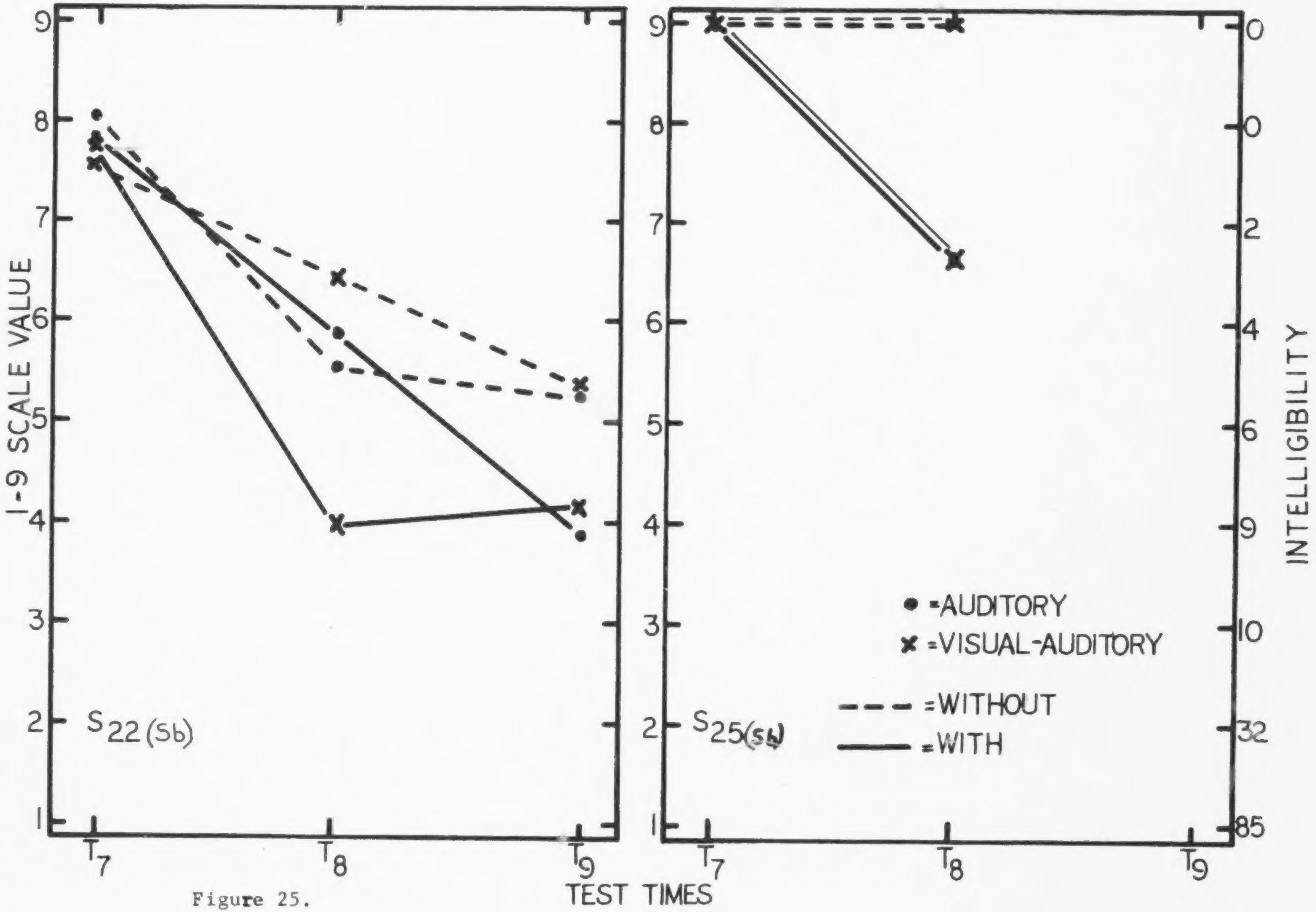

1-9 SCALE VALUE
INTELLIGIBILITY
TEST TIMES
T_7
T_8
T_9
9
8
7
6
5
4
3
2
1
0
0
2
4
6
9
10
32
85
S_{22} (Sb)
S_{25} (Sb)
● =AUDITORY
✖ =VISUAL-AUDITORY
- - - =WITHOUT
—— =WITH

Figure 25.

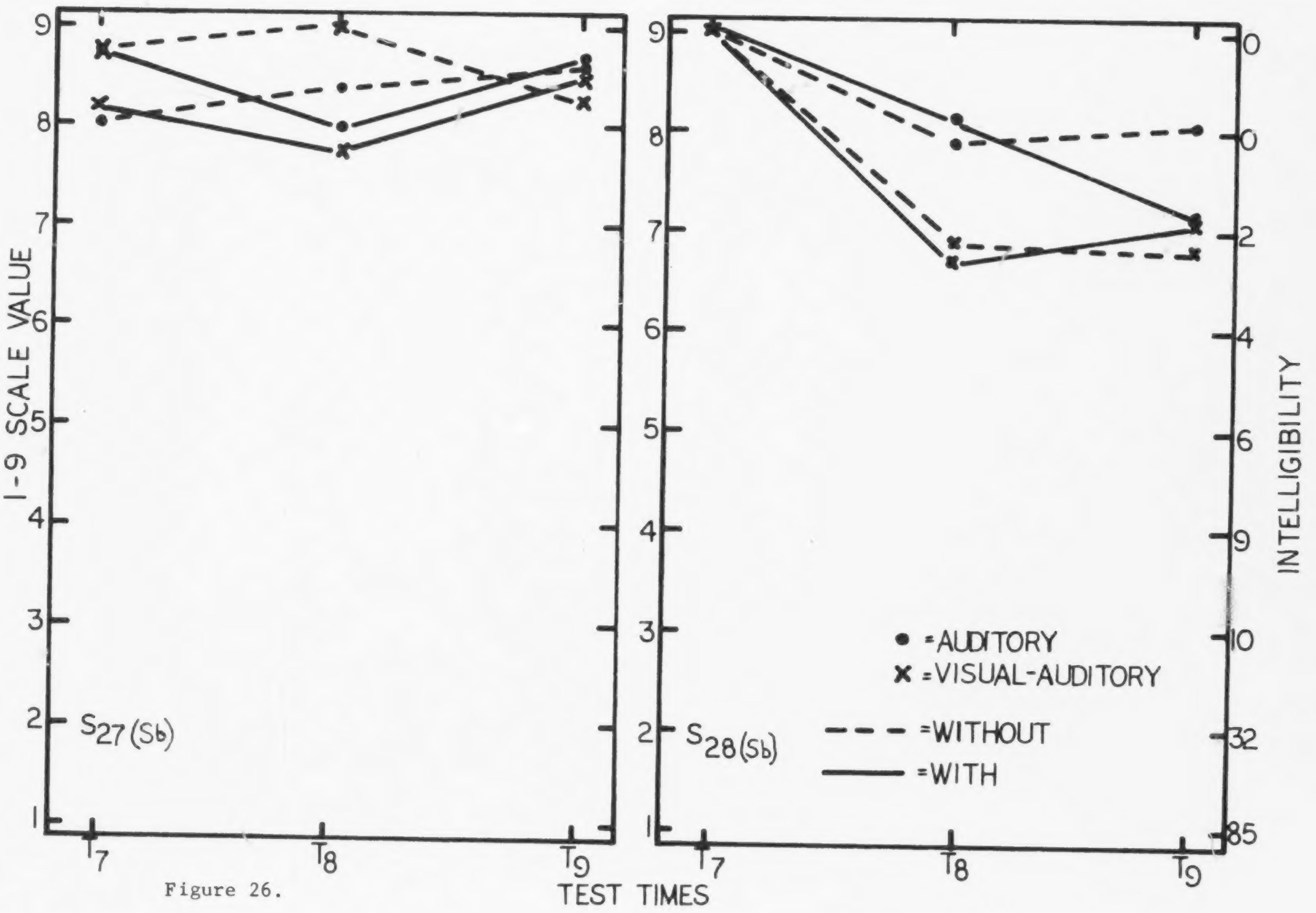
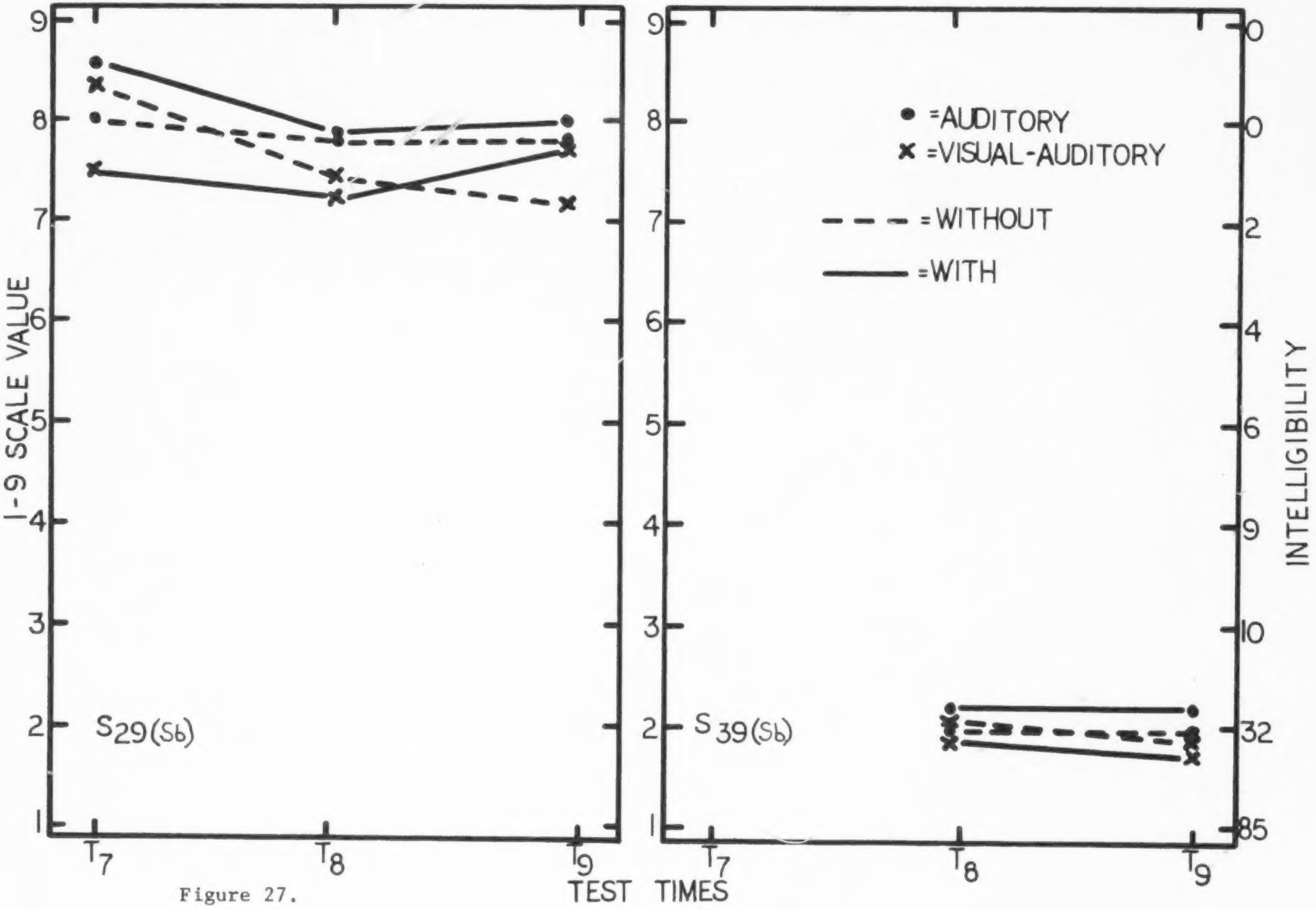

1-9 SCALE VALUE
9
8
7
6
5
4
3
2
1
S27(Sb)
S28(Sb)
T7
T8
T9
TEST TIMES
INTELLIGIBILITY
0
0
2
4
6
9
10
32
85
● =AUDITORY
✕ =VISUAL-AUDITORY
- - - =WITHOUT
—— =WITH

Figure 26.



1-9 SCALE VALUE
9
8
7
6
5
4
3
2
1
S29(Sb)
S 39(Sb)
T7
T8
T9
TEST TIMES
● =AUDITORY
× =VISUAL-AUDITORY
= WITHOUT
=WITH
INTELLIGIBILITY
0
0
2
4
6
9
10
32
85

Figure 27.

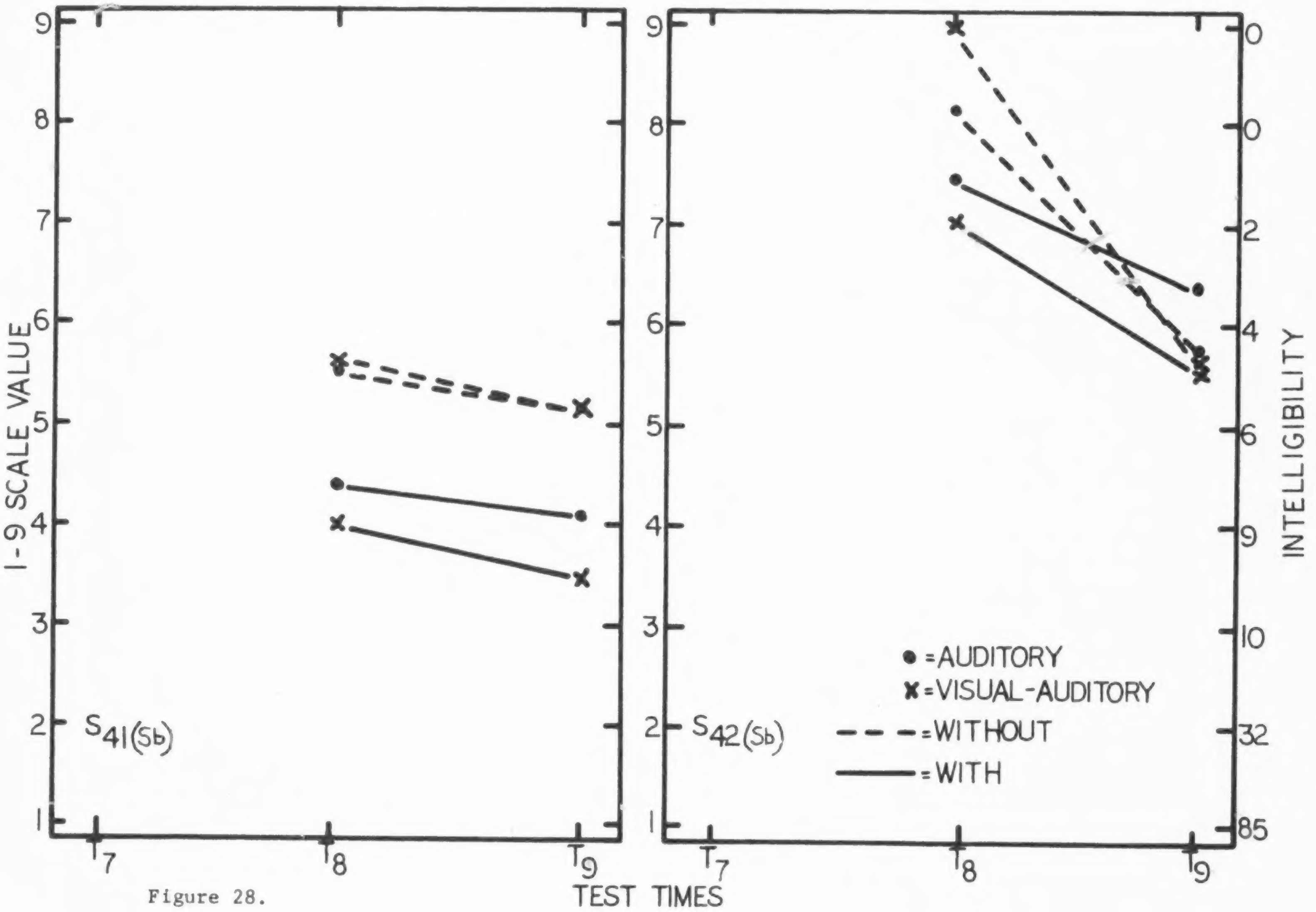

1-9 SCALE VALUE
9
8
7
6
5
4
3
2
1
S41(Sb)
T7
T8
T9
S42(Sb)
● =AUDITORY
x =VISUAL-AUDITORY
- - - =WITHOUT
—— =WITH
INTELLIGIBILITY
0
0
2
4
6
9
10
32
85
TEST TIMES

Figure 28.

Figure 28 displays the mean for S41 and S42. S41 has a noticeable separation in four test conditions over T8 and T9. S41 performs noticeably better in the condition with amplification. He has some behavioral problems, but his prognosis for auditory perception is excellent.

S42 demonstrates a marked improvement from T8 through T9. It is interesting to note that the conditions without amplification showed the most improvement. This child has an 83 dB hearing loss and has a parent who is deaf. The prognosis for continued improvement in auditory perception is excellent.

Warren, Individual Graphs

Figures 24, 29, 30, and 31 display the mean for seven subjects in this group. Figure 24 displays the mean for S26 on the right hand side of the graph. The greatest improvement for this child is between T8 and T9. The condition with amplification and visual clues were the best at T9. This child has a 90 dB hearing loss.

Figure 29 displays the means for S31 and S33. S31 has a noticeable separation between the four conditions but does not demonstrate any noticeable improvement over the three testing times. The subject has a relatively flat audiogram with the hearing loss being 78 dB for the speech frequencies. The prognosis for this child for auditory perception at the outset of the therapy was good to excellent. However, this child has not improved over these testing times. S33 demonstrates the most improvement from T7 to T9 in the condition with amplification.

Figure 30 displays the mean for S35 and S36. S35 shows a marked improvement in the conditions with amplification, whereas there is little or no improvement with the conditions without amplification. The hearing loss is 95 dB in the speech frequencies. This child has normal intonation and rhythm patterns and the prognosis for auditory perception is excellent.

S36 demonstrates some improvement from T7 through T9. At the outset of the program the prognosis for this child in auditory perception was excellent; however, the improvement as measured by the 1-9 was limited.

Figure 31 displays the mean for S37 and S38. S37 has a 51 dB hearing loss and is considered hard-of-hearing. She did not demonstrate any noticeable improvement from T7 through T9, but scored very low on the 1-9 scale. This child had some very definite emotional problems at the outset of therapy, but her improvement in auditory perception within the classroom has seemed to make her more confident in communication. This child is presently attending a normal-hearing first grade and appears to have adjusted to that situation.

S38 has poor scores from T9 and T8. It was not possible to get a reliable audiogram for this child, but she did have an awareness of speech at 80 dB. This child was very hyperactive and was under medication during most of her time in therapy.

Summary of Individual Graphs

Table 15 displays the correlation coefficients for a number of paired variables. The first two columns in the Table identify these paired variables. Column three identifies the number of subjects in the comparison, and column four identifies the Pearson Product Moment Correlation Coefficient. Column five identifies the significance level.

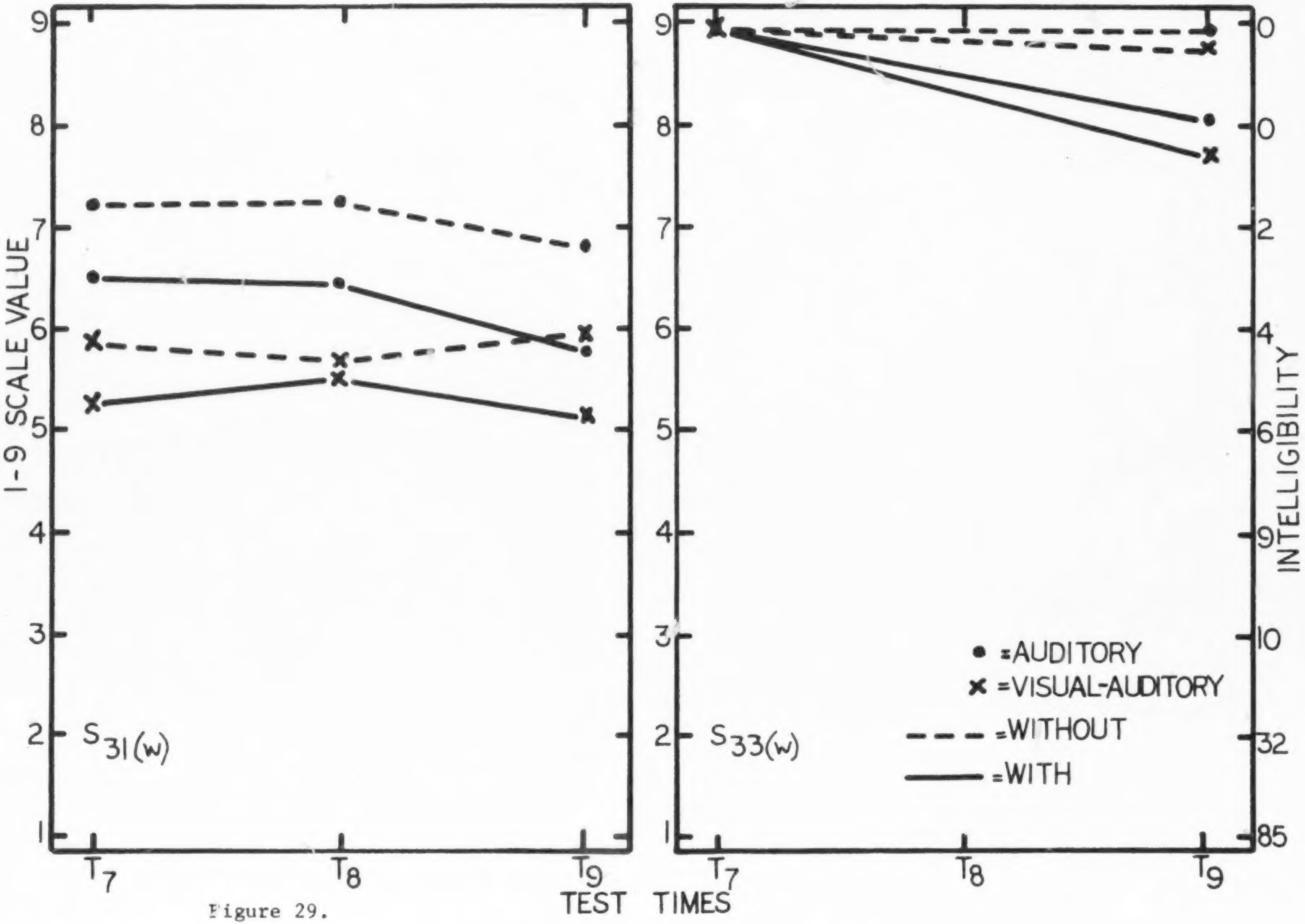

1-9 SCALE VALUE
INTELLIGIBILITY
9
8
7
6
5
4
3
2
1
0
0
2
4
6
9
10
32
85
S31(w)
S33(w)
T7
T8
T9
TEST TIMES
• =AUDITORY
x =VISUAL-AUDITORY
- - - =WITHOUT
—— =WITH

Figure 29.

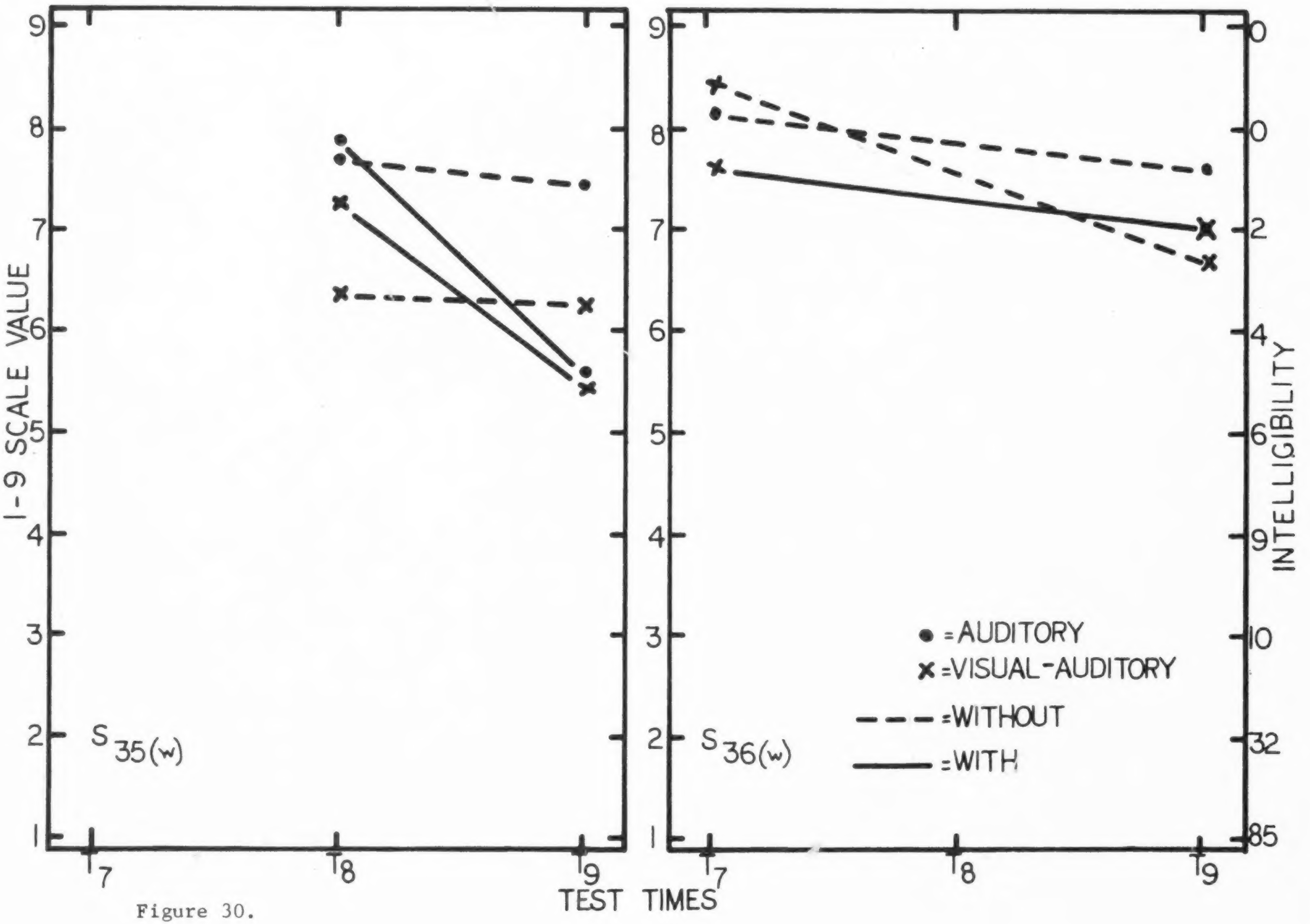

1-9 SCALE VALUE
9
8
7
6
5
4
3
2
1
S 35(w)
T7
T8
T9
TEST TIMES
S 36(w)
T7
T8
T9
INTELLIGIBILITY
0
0
2
4
6
9
10
32
85
● =AUDITORY
✕ =VISUAL-AUDITORY
- - - =WITHOUT
—— =WITH

Figure 30.

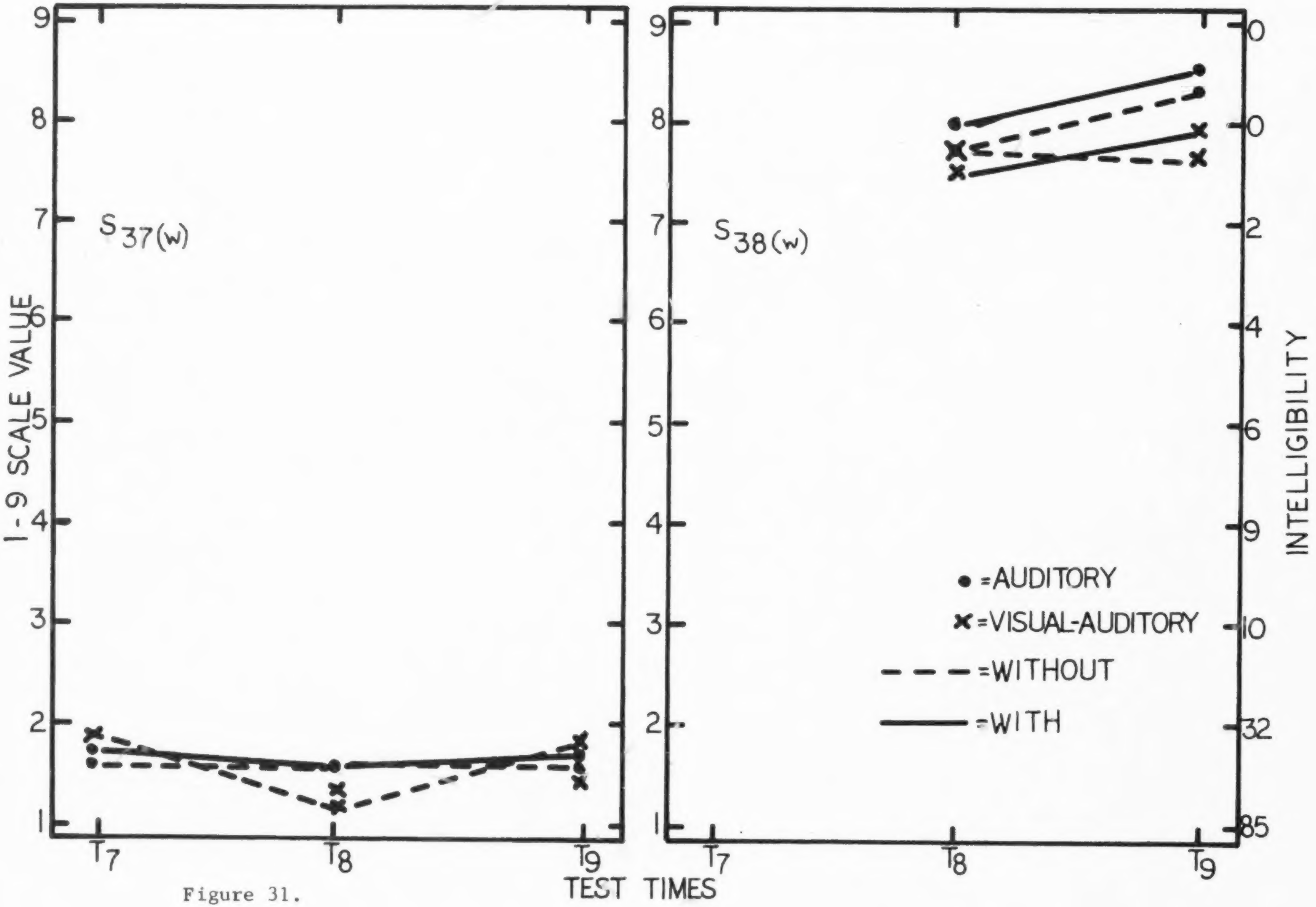

S37(w)
S38(w)
1-9 SCALE VALUE
INTELLIGIBILITY
TEST TIMES
T7
T8
T9
1
2
3
4
5
6
7
8
9
0
0
2
4
6
9
10
32
85
• =AUDITORY
× =VISUAL-AUDITORY
- - - =WITHOUT
—— =WITH

Figure 31.

TABLE 15

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS FOR DIFFERENT PAIRED VARIABLES

Paired Variables		Number of Subjects	Correlation Coefficient	Significance Level
Variable X	Variable Y			
1-9	HTL	23	.86	.001
1-9	I.Q.	19	-.01	.485
1-9	Total T.H.	25	-.30	.075
1-9	DURATION	16	.38	.071
1-9	RATE	16	.18	.250
1-9 DIFFERENCE	T.H.	25	.13	.267
HTL	DURATION	15	.29	.150
HTL	RATE	15	.16	.283

KEY:

1-9	Mean 1-9 Score for each Subject for the latest recording time (T_8 or T_9) for this evaluation
1-9 Difference	The earliest 1-9 Score minus the latest 1-9 Score for T_7-T_9
I.Q.	As measured by the Leiter Performance Scale
T.H.	Therapy Hours for T_7, T_8, and T_9
Total T.H.	Total therapy hours in the preschool program
DURATION	Mean duration in msec for each child's vocalizations
RATE	Mean rate of vocalizations per minute
HTL	Mean 2-frequency pure-tone average in the better ear

As can be observed there is a .86 correlation between the 1-9 values and the hearing threshold levels (HTL) of the children. In other words, the more hearing a child has as measured by the pure-tone audiogram, the more intelligible will be his speech as measured by the 1-9 scale. This correlation coefficient is significant. However, some children with more hearing do not perform as well as others in the therapy situation.

The correlation coefficient between the 1-9 scale and I.Q. measures was zero. This indicates no correlation between the I.Q. of the child and his ability to utilize his residuum of hearing as measured on the 1-9 scale.

There is a correlation coefficient of -.30 for the relationship between the 1-9 rating values and the total therapy hours. This indicates that as the therapy hours increase the child improves and scores better on the 1-9 scale.

The correlation coefficient between the 1-9 scale value and the mean duration of the vocalization was .38. This indicates that children with a shorter mean duration score better on the 1-9 scale. This is understandable because the speech patterns are closer to that of the normal-hearing person. This finding may eventually differentiate between children with similar hearing losses. The child with the shorter duration would have the better prognosis.

Another interesting correlation coefficient is the .29 for the comparison between HTL and the duration of vocalizations. This would indicate that children with better hearing have a lower mean duration and would have a better prognosis for improving in auditory perception and speech production.

We are attempting to identify other variables that may be important in determining the rate of improvement for preschool deaf children. As these variables are identified and evaluated the results will be discussed in future reports.

CHAPTER IV
VOCALIZATION RATE AND DURATION

Rationale

A frequent comment of visitors who observe our program is that most of the children in our program have "normal" pitch and voice quality. To evaluate these observations, it was necessary to design and construct electronic instrumentation for obtaining objective measures on the speech patterns of our children. The reader is referred to Chapter IX for the design of some of these systems.

Another reason for obtaining objective speech pattern measures is that we have observed that children with similar pure-tone audiograms perform very differently in acquiring auditory perception and speech production. This seems to indicate that the pure-tone test is not able to differentiate between these children and to counteract the diagnostic limitations of pure-tone testing we are also using filtered-speech testing to aid in this differentiation.

Another possible tool is the analysis of the children's speech patterns. If we can assume that the speech patterns of the preschool deaf child are an indication of how he perceives, then objective measures of these speech patterns may differentiate children with similar pure-tone audiograms. For example, a child that has a high rate of vocalization probably vocalizes because he has developed some auditory perception from monitoring his vocalizations.

Another parameter to measure is the duration of the vocalizations. A normal-hearing and speaking person generally produces five syllables per second, e.g., "one thousand and one" should consume one second's time. Five syllables per second results in each syllable being approximately one-fifth of a second or a duration of 200 msec. As we, and others have observed, the unintelligible speech patterns of some deaf speakers are characterized by temporal patterns that are inordinately long in duration. As a result, preschool deaf children that have mean vocalization durations that are significantly longer than the norm, probably have a poorer prognosis for auditory perception and speech production than children who have shorter durations.

It would then be interesting to observe if these patterns change as a function of Verbo-tonal therapy and/or the type of amplification the children receive. As a result, the following measures are being obtained and analyzed: (1) the rate of vocalization, (2) the mean duration of the vocalizations, and (3) the fundamental frequency. The first two measures will be treated in this chapter and the third measure will be treated in Chapter V.

For a better understanding of measuring vocalizations, it would be helpful to review some data from two related research projects. The latter data may serve as a reference for comparing the data obtained during the period of the Preschool research grant.

Related, Earlier Research Projects

At the 81st meeting of the Acoustical Society of America in Washington, D.C., in April, 1971, a paper was presented on "The Rate of Vocalization of Deaf and Normal-hearing Children", by Carl Asp, Scott Wood, and James Keller. This paper is reproduced in Chapter X of this Report. This study measured the vocalizations of 65 deaf children and 48 normal-hearing children at age levels of 5, 7, 10, 13 and 17 years. All measures for both groups were obtained during the lunch period when the subjects were seated in their respective school cafeterias. Each subject was fitted with a throat microphone and an FM transmitter-receiver, designed by James Keller. This allowed the experimenter to obtain measurements from a remote location. Figure 32 displays a block diagram of the FM system. An automatic system allowed five-minute samples on each subject.

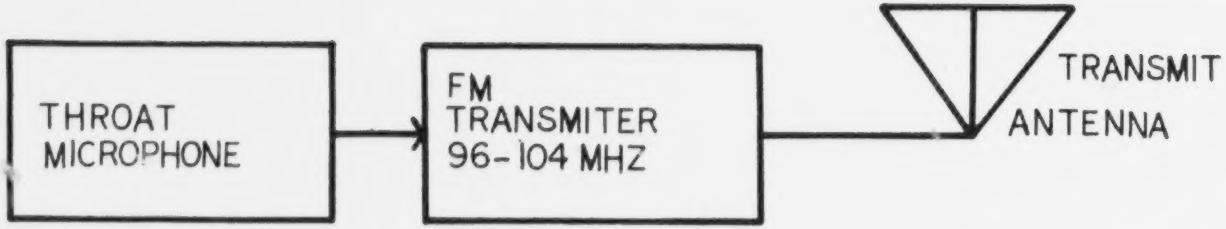
These samples were converted to mean number of vocalizations per minute for each subject. A 2-factor analysis of variance (Winer, 1962) was utilized to test the two groups and the five age levels. Table 16 displays the summary table for the analysis of variance. The between group F-ratio of 163 indicated a significant difference between the groups. The mean number of vocalizations for 48 normal-hearing subjects was 23.05; whereas, it was 3.36 for the 65 deaf subjects. In other words, the normal-hearing subjects vocalized 16.69 more times per minute than did the deaf subjects.

The right half of Figure 33 displays the means for the normal-hearing and deaf children over these five age levels. As can be observed, the mean for the normal-hearing children is similar over the five age levels. However, the vocalization rate changed significantly for the deaf subjects. From age 5 to age 7 the rate increased, and then it decreased significantly for ages 10, 13 and 17. The rate of vocalization for ages 10, 13 and 17 is at such a low rate that it would be all but impossible to develop intelligible speech patterns in most of these children.

Another basic study entitled "The Measurement and Operant Conditioning of the Vocalization of Preschool Deaf Children" by Carl Asp and Connie Lawrence, was presented at the 78th meeting of the Acoustical Society of America in November, 1969. This study was completed prior to the inception of the preschool research grant. A copy of this paper may be viewed in Chapter X of this report. The subjects were 20 preschool deaf children enrolled in our preschool program and 41 normal-hearing children. An automatic system that included a throat microphone and a voice-operated relay was utilized to obtain 5-minute samples of the vocalizations. The criterion measure was the mean rate of vocalizations per minute for each child. A t-test for independent measures revealed a significant t-ratio of 2.62. The mean number of vocalizations for the deaf group was 5.86, whereas, it was 27.6 for the normal-hearing subjects. The mean for the preschool age levels of 2, 3, 4, and 5 years of age may be viewed in the left hand portion of Figure 33. These means in general agree with the study on the right hand portion of Figure 33 with the exception of the 5 year-old normal-hearing subjects. Based on these two studies, the mean rate of vocalizations of normal-hearing children is approximately 23 per minute. Reference will be made to this value when reporting vocalization rates of children in our experimental program.

Research Project During the Grant Period

The following measurements were collected by John Berry, a full-time teacher on the project, and covered the period from April, 1970 to December, 1970. This period comprises the last quarter of the first fiscal year and the first two quarters of the second fiscal year. The reader is referred to Table 1 for perspective of this time schedule. The testing periods reported on these measurements correspond to T_8, T_9, and T_{10}.


THROAT
MICROPHONE
FM
TRANSMITER
96-104 MHZ
TRANSMIT
ANTENNA

APPARATUS WORN BY SUBJECT

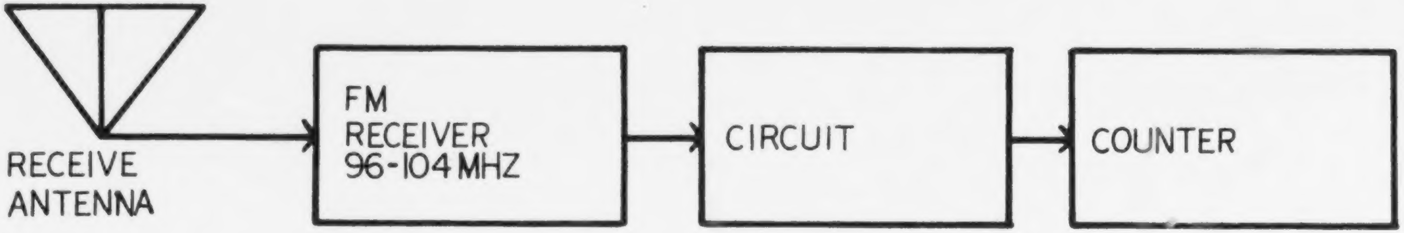

RECEIVE
ANTENNA
FM
RECEIVER
96-104 MHZ
CIRCUIT
COUNTER

Figure 32. APPARATUS OPERATED BY EXPERIMENTER

TABLE 16

SUMMARY OF A TWO-FACTOR ANALYSIS OF VARIANCE FOR GROUPS (NORMAL-HEARING AND DEAF) AND AGE LEVELS

Source of Variance	SS	df	MS	F
A (Groups)	9915.06	1	9915.06	163.91*
B (Ages)	566.89	4	141.72	2.34
AB (Interaction)	740.83	4	185.20	3.06**
Within Cells	6231.35	103	60.49	
Total	17454.13	112		

*F .05 = 4.00, df = 1/60

**F .05 = 2.53, df = 4/60

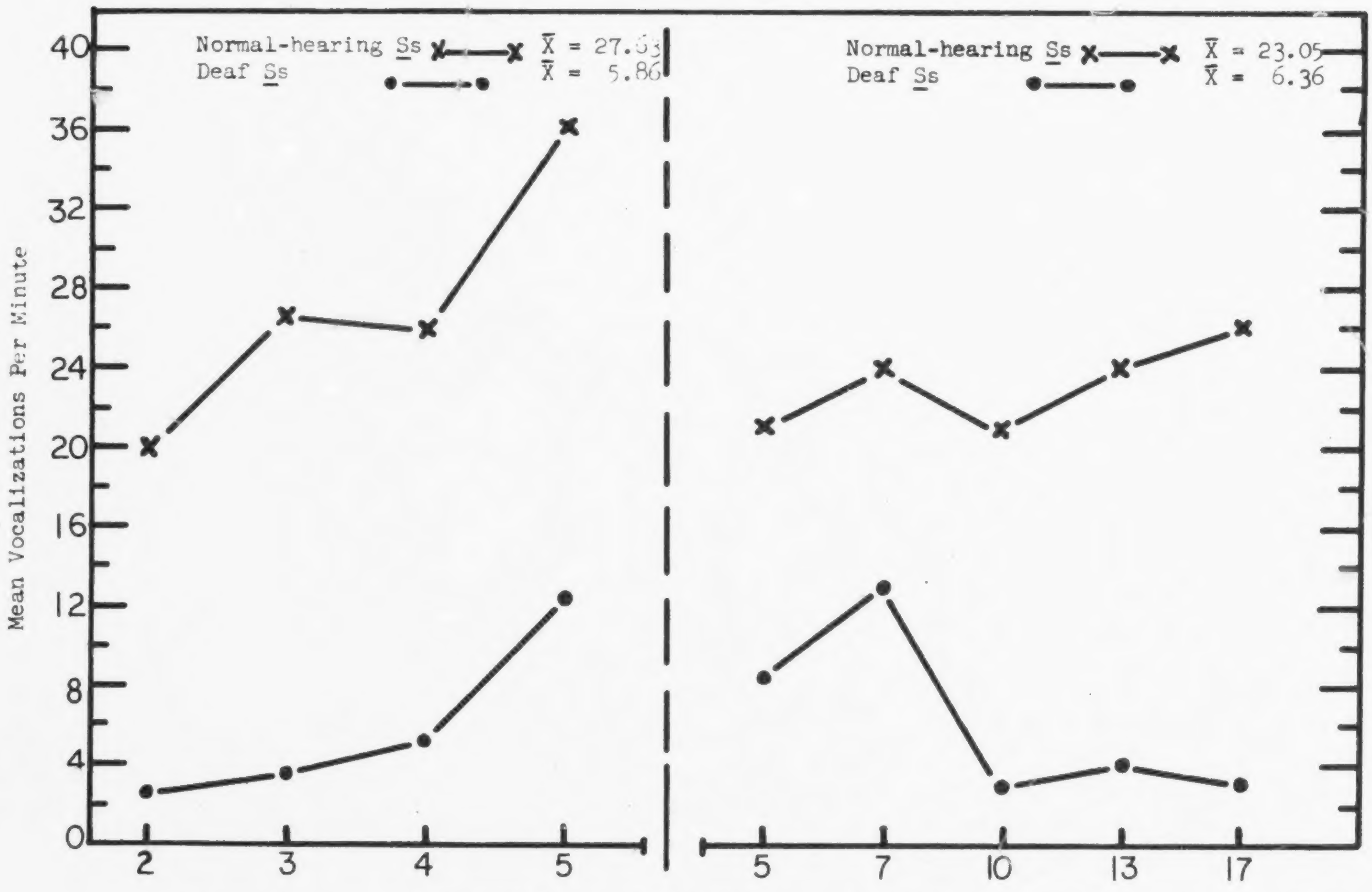


Figure 33. Mean Vocalizations Per Minute as a Function of Age

Measurements were obtained on sixteen of the children enrolled in our program with ten being assigned to the Suvag unit and six being assigned to the Warren unit. The subjects in the Suvag group are identified as Subject 8, 9, 11, 14, 16, 17, 22, 28, 29, and 41. Subjects 8 through 17 are Suvag A, and Subjects 22 through 41 are Suvag B. The Warren children are identified as Subjects 26, 31, 35, 36, 37 and 38. The reader is referred to Table 2 and Table 3a, 3b, and 3c, Chapter I, for pertinent information on these subjects. In addition, parts of the text of Chapter II pertain to these subjects.

For these sixteen subjects, the mean age of the Suvag group was 5 years with a range of 3 years, 4 months to 6 years, 2 months. The mean age of the Warren group was 4 years, 4 months, with a range of 2 years, 4 months to 5 years, 4 months.

The experimental procedure for the T_8 and the T_9 testing periods was identical. The test area consisted of a small table, two chairs, a box of small toys suitable for both males and females, and the automatic instrumentation for obtaining the measurements. The subject was taken out of class and seated at a small table to the left of the experimenter in the test area. The experimenter attempted to make the test environment a normal communicative situation. The vocalizations were picked up by a throat microphone worn by the child, transmitted to a voice-operated relay, and recorded by an electro-mechanical counter. An electro-mechanical clock was utilized to measure the "on time" of the vocal cords during the 5-minute test period. In addition, a Wollensak tape recorder was used to record all vocalizations during T_8 and T_9.

During the T_{10} testing period, the subjects were placed out of doors in a 35' x 50' play area. The instrumentation utilized for this procedure was the FM transmitter-receiver system referred to earlier in this chapter. A throat microphone was placed on the subject under test, and he was free to move about in the play area. The automatic FM system allowed the experimenter to obtain measures from a remote location.

A mean number of eight 5-minute measurements were obtained on each subject over these three test periods. The tape-recorded samples obtained in T_9 and T_{10} were simultaneously analyzed by two independent systems. One system was the standard voice-operated relay (Grason-Stadler Model E7300 A-1) and the other was a unit designed by our engineer, James Keller, and identified as the VDRK.

The criterion measures for the analysis were as follows: (1) the mean rate of vocalizations per minute for each test time for each child, and (2) the mean duration of vocalizations for each test time for each child. These criterion measures were analyzed by a 2-factor analysis of variance with repeated measures on one measure (Winer, 1962). The results of the analysis will be discussed first for the rate of vocalizations, and secondly for the duration of vocalizations as measured by the two units.

With regard to the rate of vocalizations, Table 17 displays a summary of the analysis of variance for the data as measured by the VOR unit, and Table 18 displays a summary of the analysis of variance of the data as measured by the VDRK unit. The between group F-ratio for the VOR unit was 3.23, while for the VDRK unit it was 4.8. The latter F-ratio was significant at the .05 level. The mean rate of vocalizations for each group as displayed in Table 4, was as follows: (1) Suvag groups- 21 for the VOR unit, and 23 for the VDRK unit; and (2) Warren group- 15 for the VOR unit and 14 for the VDRK unit. In the case of the latter, the Suvag

TABLE 17

SUMMARY OF ANALYSIS OF VARIANCE FOR MEAN RATE OF VOCALIZATIONS FOR GROUPS (SUVAG vs WARREN), TIME (T_8, T_9, and T_{10}), AND THE INTERACTION (GT) AS MEASURED ON THE VOR UNIT

Source of Variation	SS	df	MS	F
Between subjects		15		
G (SUVAG vs Warren)	460.508	1	460.50	3.23
Subjects w group	1,997.538	14	142.68	
Within subjects		32		
T (Time)	2,730.538	2	1,365.27	31.93*
GT	21.553	2	10.78	.25
T x subjects w group	1,197.384	28	42.76	
Total	6,407.521	47		

*$F_{.05}$ (3.34), df = 2/28.

TABLE 18

SUMMARY OF ANALYSIS OF VARIANCE FOR MEAN RATE OF VOCALIZATIONS FOR GROUPS (SUVAG vs WARREN), TIME (T_9 AND T_{10}), AND THE INTERACTION (GT) AS MEASURED ON THE VDRK UNIT

Source of Variation	SS	df	MS	F
Between subjects		15		
G (SUVAG vs Warren)	619.355	1	619.36	4.805*
Subjects w groups	1,804.536	14	128.896	
Within subjects		16		
T (Time)	1,206.376	1	1,206.38	18.648**
GT	105.696	1	105.70	1.63
T x subjects w groups	905.654	14	64.69	
Total	4,641.617	31		

*$F_{.05}$ (4.60), df = 1/14.
**$F_{.05}$ (4.60), df = 1/14.

group vocalizes five more times per minute than the Warren group.

The within-subject F-ratio for testing times was significant as measured by both units. The mean rate of each group as measured by the two units is displayed in Figure 34. As may be observed, the Suvag children vocalized more times per minute that did the Warren children at all three testing times. This would seem to suggest that the low-frequency amplification of the Suvag unit produced a higher rate of vocalization in these children. Table 19 shows these mean values.

It should be noted also in Figure 34 that the rate increased for both groups from T_9 to T_{10}. Part of this increase was possibly due to the measurements being obtained on the playground for the T_{10} testing time.

With regard to the duration of the vocalization, Table 20 displays a summary of the analysis of variance for the data as measured by the VOR unit, and Table 21 displays a summary of the analysis of variance of the data as measured by the VDRK unit. The between-group ratios were 1.58 and 1.3, respectively. The mean duration for the three measurement times for both units may be viewed in Table 22 . The group means are plotted and may be viewed in Figure 35. The analysis of variance for the VOR unit covers all three test periods, and the analysis of variance for the VDRK unit covers only the last two periods

It may be observed in Figure 35 that the duration of the Suvag children is considerably greater than that of the Warren children at T_8. This is an important finding because the longer duration tends to indicate a poor prognosis for improvement in auditory perception and speech production. Although these children were matched in hearing levels it is apparent that they were not matched in the duration of their vocalizations. For both groups there was a significant decrease in duration across T_9 and T_{10}. This was detected by the significance in the F-ratio across these times as displayed in Table 20. Both groups decreased significantly over time and had shorter duration for T_{10}. This would seem to indicate that the Verbo-tonal therapy procedures bring the duration of vocalizations closer to that of a normal-hearing person (200 milliseconds).

Further Research Comparing Free-Play and Structural Vocalizations

Rate and duration measurements were obtained during the summer session of 1971 (equivalent to testing time T_{12}). These measures were obtained by Fred Miller, research assistant, who utilized the FM system designed by James Keller. His measures were obtained and analyzed in a live-voice situation rather than being tape recorded and analyzed later. An electromechanical counter recorded the number of vocalizations during the 5-minute period, and an electronic counter accumulated the total "on time" of the vocalizations for the 5-minute period. The total "on time" was divided by the total number of vocalizations to yield the mean duration per vocalization.

A total of 26 children were measured. Of these, 17 were Suvag children and 9 were Warren children. The children were measured under both a structured situation and a free-play situation. A situation was considered structured if the child was in a formal therapy situation; it was considered free-play if it was a recreation period when the child was free to move about the play area.

RATE OF VOCALIZATIONS AS MEASURED BY TWO INSTRUMENTS

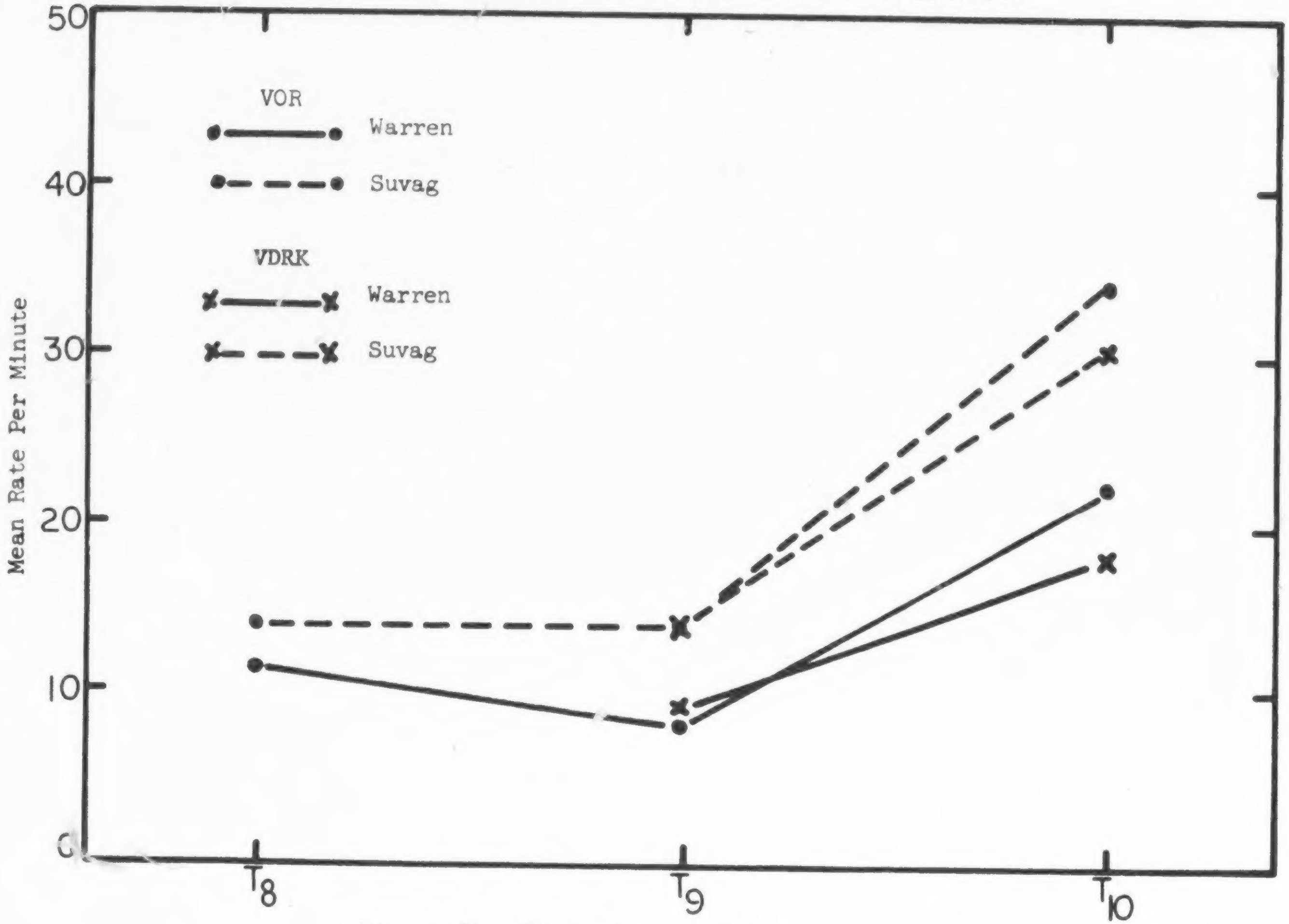


Figure 34. Test Times or Dates

TABLE 19

THE MEAN RATE OF VOCALIZATION PER MINUTE FOR EACH TEST PERIOD (T_8,T_9,T_{10}) ON EACH SUBJECT IN BOTH THE SUVAG AND WARREN GROUPS AS MEASURED BY THE VOR UNIT AND VDRK UNIT

SUVAG SUBJECTS	T 8		T 9		T 10	
	VOR	VDRK	VOR	VDRK	VOR	VDRK
S_8(Sa)	14	---	17	13	33	30
S_9(Sa)	10	---	27	30	27	26
S_{11}(Sa)	22	---	23	29	57	49
S_{14}(Sa)	27	---	24	25	42	35
S_{16}(Sa)	10	---	4	4	52	50
S_{17}(Sa)	14	---	15	14	39	39
S_{22}(Sb)	15	---	7	6	27	28
S_{28}(Sb)	9	---	3	3	20	15
S_{29}(Sb)	11	---	7	9	17	15
S_{41}(Sb)	10	---	12	11	30	23
MEAN	14	---	14	14	34	31

WARREN SUBJECTS	T_8		T_9		T_{10}	
	VOR	VDRK	VOR	VDRK	VOR	VDRK
S_{26} (W)	10	---	12	14	25	19
S_{31} (W)	14	---	9	9	26	17
S_{35} (W)	3	---	3	2	17	15
S_{36} (W)	5	---	2	1	20	12
S_{37} (W)	14	---	16	18	17	17
S_{38} (W)	24	---	12	12	33	28
MEAN	12	---	9	9	23	18

TABLE 20

SUMMARY OF ANALYSIS OF VARIANCE FOR MEAN DURATION OF VOCALIZATIONS FOR GROUPS (SUVAG vs WARREN), TIME (T_8, T_9, AND T_{10}), AND THE INTERACTION (GT) AS MEASURED ON THE VOR UNIT

Source of Variation	SS	df	MS	F
Between subjects		15		
G (SUVAG vs Warren)	37,521.022	1	37,521	1.58
Subjects w group	332,098.010	14	23,721	
Within subjects		32		
T (Time)	107,717.859	2	53,859	6.631*
GT	6,608.743	2	3,305	0.406
T x subjects w groups	227,410.855	28	8,122	
Total	711,356.489	47		

$^*F_{.05}$ (3.34), df = 2/28.

TABLE 21

SUMMARY OF ANALYSIS OF VARIANCE FOR MEAN DURATION OF VOCALIZATIONS FOR GROUP (SUVAG vs WARREN), TIME (T_9 AND T_{10}), AND THE INTERACTION (GT) AS MEASURED ON THE VDRK UNIT

Source of Variation	SS	df	MS	F
Between subjects		15		
G (SUVAG vs Warren)	11,718.081	1	11,718.081	1.332
Subjects w group	123,088.442	14	8,792.031	
Within subjects		16		
T (Time)	108.846	1	108.846	.021
GT	2,873.695	1	2,873.695	.56
T x subjects w groups	71,459.152	14	5,104.225	
Total	209,248.216	31		

TABLE 22

THE MEAN DURATION OF VOCALIZATION PER MINUTE FOR EACH TEST PERIOD (T_8,T_9,T_{10}) ON EACH SUBJECT IN BOTH THE SUVAG AND WARREN GROUPS AS MEASURED BY THE VOR UNIT AND VDRK UNIT

SUVAG SUBJECTS	T_8		T_9		T_{10}	
	VOR	VDRK	VOR	VDRK	VOR	VDRK
S_8 (Sa)	330	---	229	217	227	238
S_9 (Sa)	201	---	238	221	218	262
S_{11} (Sa)	635	---	490	404	237	251
S_{14} (Sa)	411	---	355	320	271	307
S_{16} (Sa)	388	---	389	267	246	268
S_{17} (Sa)	290	---	201	176	222	288
S_{22} (Sb)	409	---	270	312	296	299
S_{28} (Sb)	385	---	322	384	229	267
S_{29} (Sb)	425	---	597	372	217	287
S_{41} (Sb)	509	---	355	307	354	356
MEAN	398	---	345	298	252	282

WARREN SUBJECTS	T_8		T_9		T_{10}	
	VOR	VDRK	VOR	VDRK	VOR	VDRK
S_{26} (W)	358	---	362	295	204	290
S_{31} (W)	462	---	258	218	230	275
S_{35} (W)	129	---	101	126	158	181
S_{36} (W)	148	---	102	46	231	214
S_{37} (W)	392	---	307	263	267	343
S_{38} (W)	371	---	605	485	243	270
MEAN	310	---	289	239	222	262

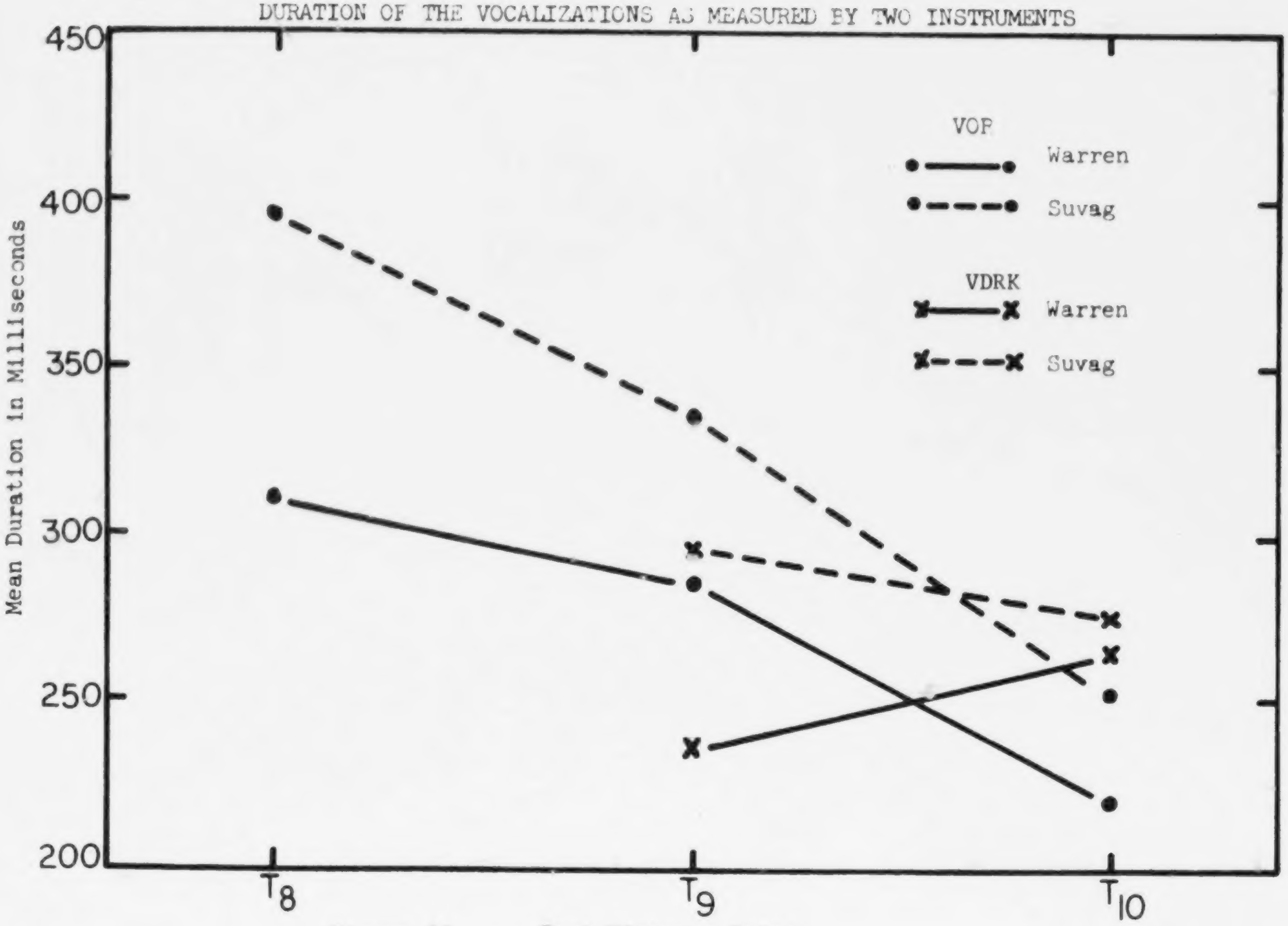


Figure 35. Test Times or Dates

From September, 1971, to February, 1972, live-voice rate and duration measurements were obtained by Tom Rothaar, a graduate research assistant on the project. These measurements, which were obtained in both a structured and free-play situation, will be analyzed at a later time. Both the live-voice measurements by Fred Miller and those by Tom Rothaar will be reported in a later report.

Another source of rate and duration measures that has been utilized is the speech samples that were obtained for the 1-9 rating scale. In this situation the teacher presents 27 words in four different test conditions for each testing time. The child attempts to imitate the stimulus. Tom Rothaar has been able to analyze some of these samples for a few children from T_8 through T_{12}. The following paragraphs will include a discussion of some of these measures.

Figure 36 displays the mean values for four Suvag A subjects (S_{11}, S_{14}, S_9, S_8). The rate of vocalizations for each of these subjects was measured over the period of T_8 through T_{12}. In addition, the mean rate for normal-hearing children (23 per minute) is indicated on the ordinate of this and the succeeding three graphs as the letter N. The mean rate for the deaf children at the residential school is 6.4 and is identified by D on each of these graphs. As can be observed, the four Suvag A subjects demonstrate a considerable variability over these five test periods. For most of these subjects, this rate is near the rate of normal-hearing children.

Figure 37 displays the rate for four Suvag B subjects (S_{29}, S_{41}, S_{22}, S_{28}). As can be observed, the Suvag B children show a noticeable increase at T_{10}. When compared to the Suvag A group, this group is observed to have vocalized less.

Figure 38 displays the vocalization rate of four Warren children (S_{35}, S_{26}, S_{37}, S_{36}). Measurements are plotted for the four subjects for T_8, T_9, T_{10}; but only two subjects were measured at T_{12}, and no subjects were measured at T_{11}. These Warren subjects seem to have a similar rate to that of the Suvag B children.

Figure 39 displays the rate of two Warren subjects (S_{31}, S_{38}). These two subjects show great variability in rate over the period from T_8 to T_{10}.

In all of the figures displayed above, the rate of vocalizations for both the Suvag and the Warren children was significantly above that of the residential school children. With regard to systems of amplification, it appeared that the Suvag A group vocalized significantly more than the Suvag B or the Warren group. Additional measures are needed before these values can be analyzed in an analysis of variance.

Tom Rothaar has also measured the duration of some of the recorded speech samples that were obtained for the 1-9 rating scale. The following graphs will display some of the measures.

Figure 40 displays the mean duration for two Suvag A and two Suvag B subjects over the period T_8 through T_{12}. As can be observed, S_{11}(Sa) shows a significant decrease from over 600 msec to approximately 250 msec over this measurement period. This would tend to indicate a singificant improvement in the speech patterns of this child. In addition, the other three subjects appear to be decreasing in the duration of their vocalizations over this testing time. At T_{12}, all four subjects have a mean duration of less than 340 msec which is close to that of a normal-hearing person.

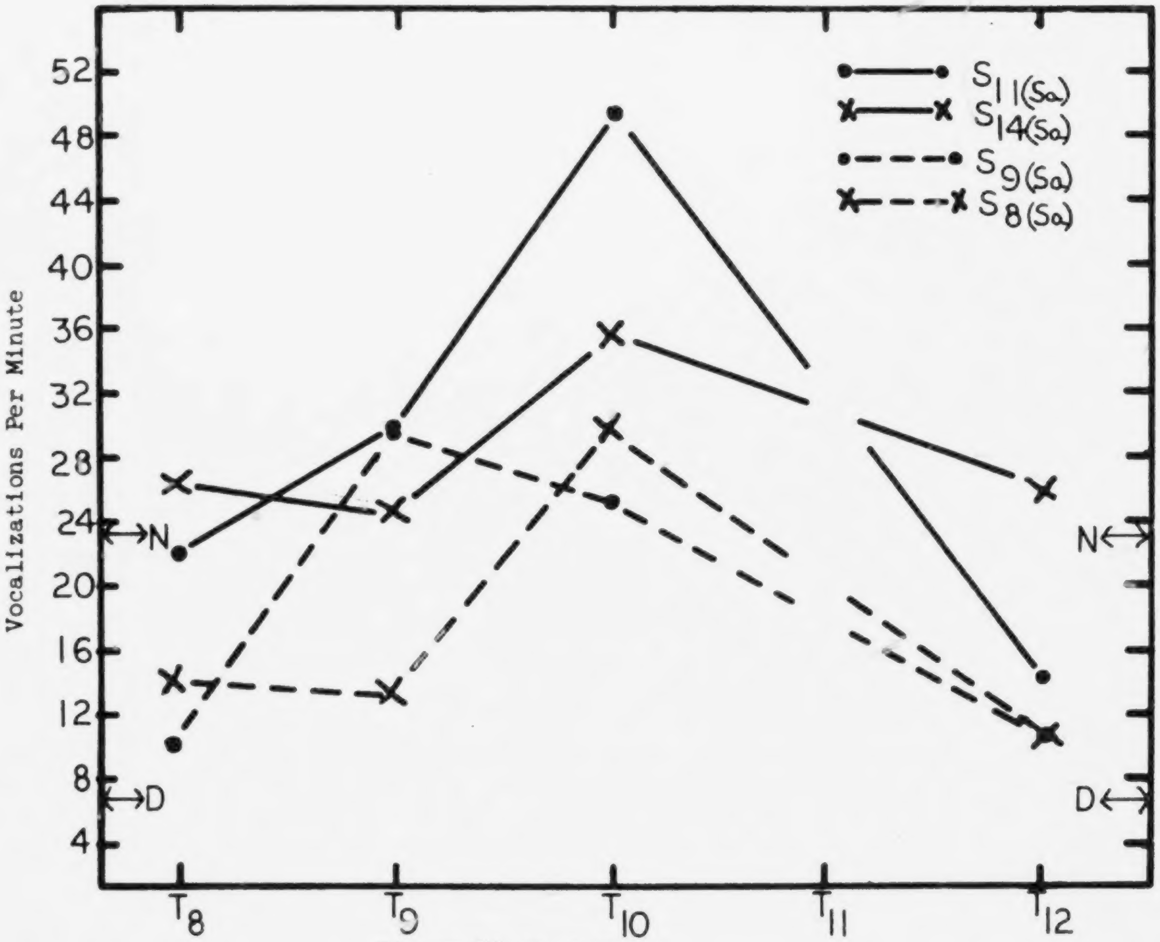


Figure 36. Test Times

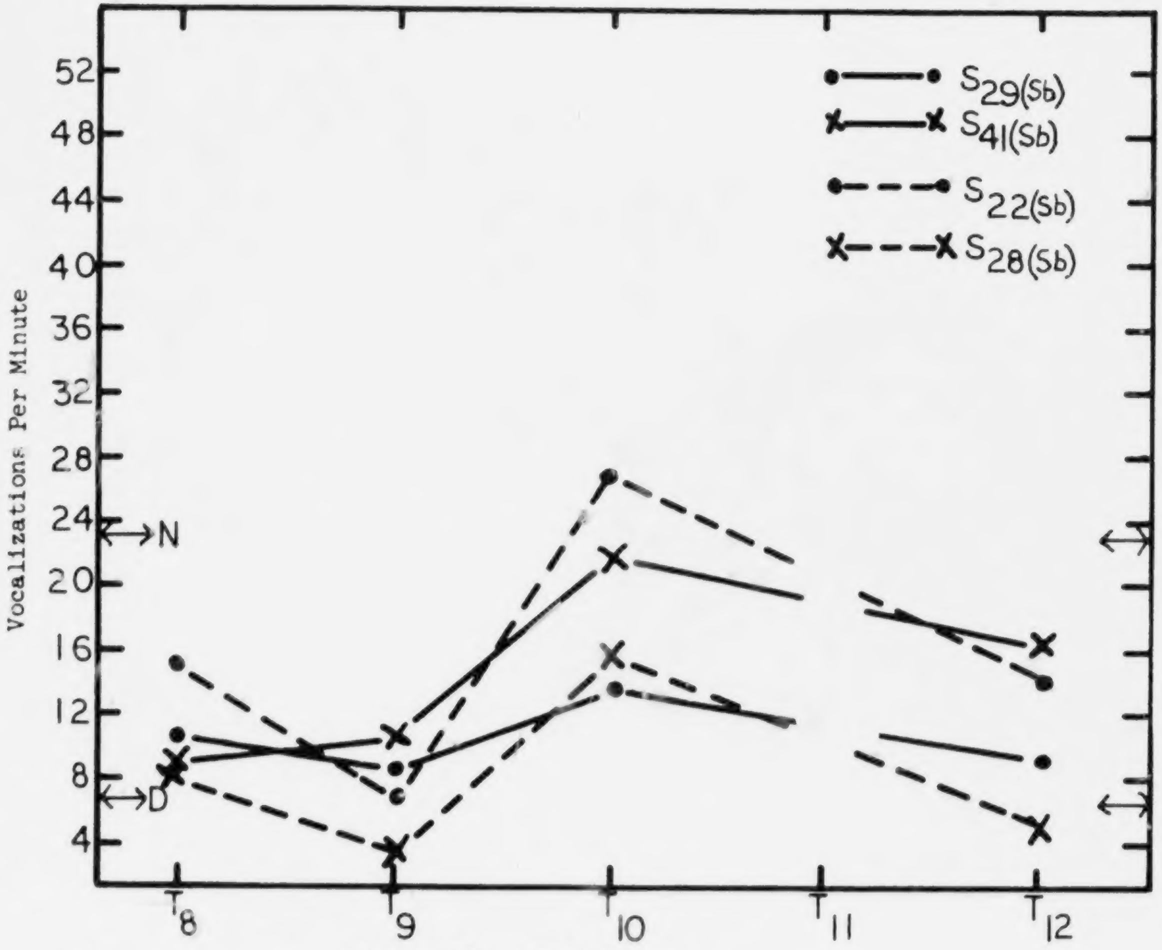


Figure 37.   Test Times

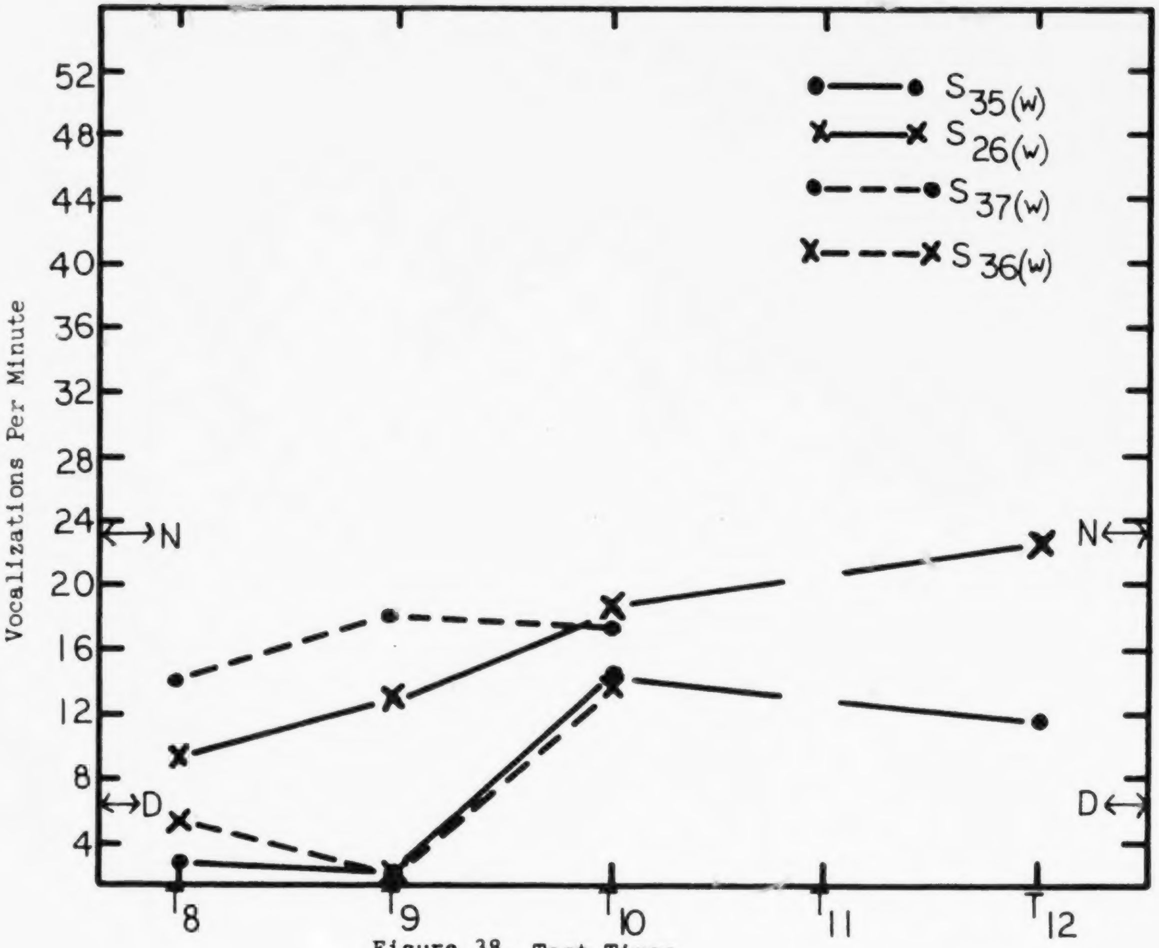


Figure 38. Test Times

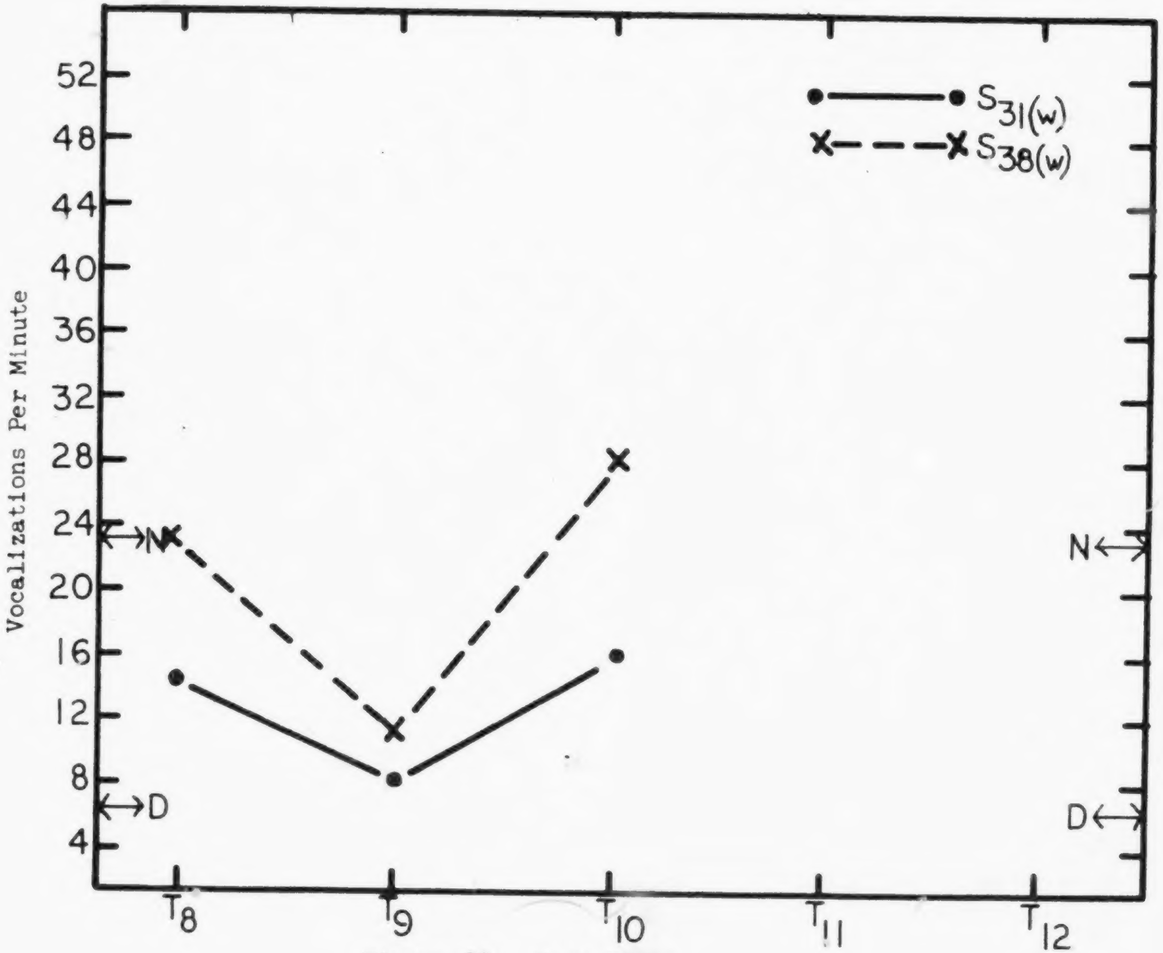


Figure 39. Test Times

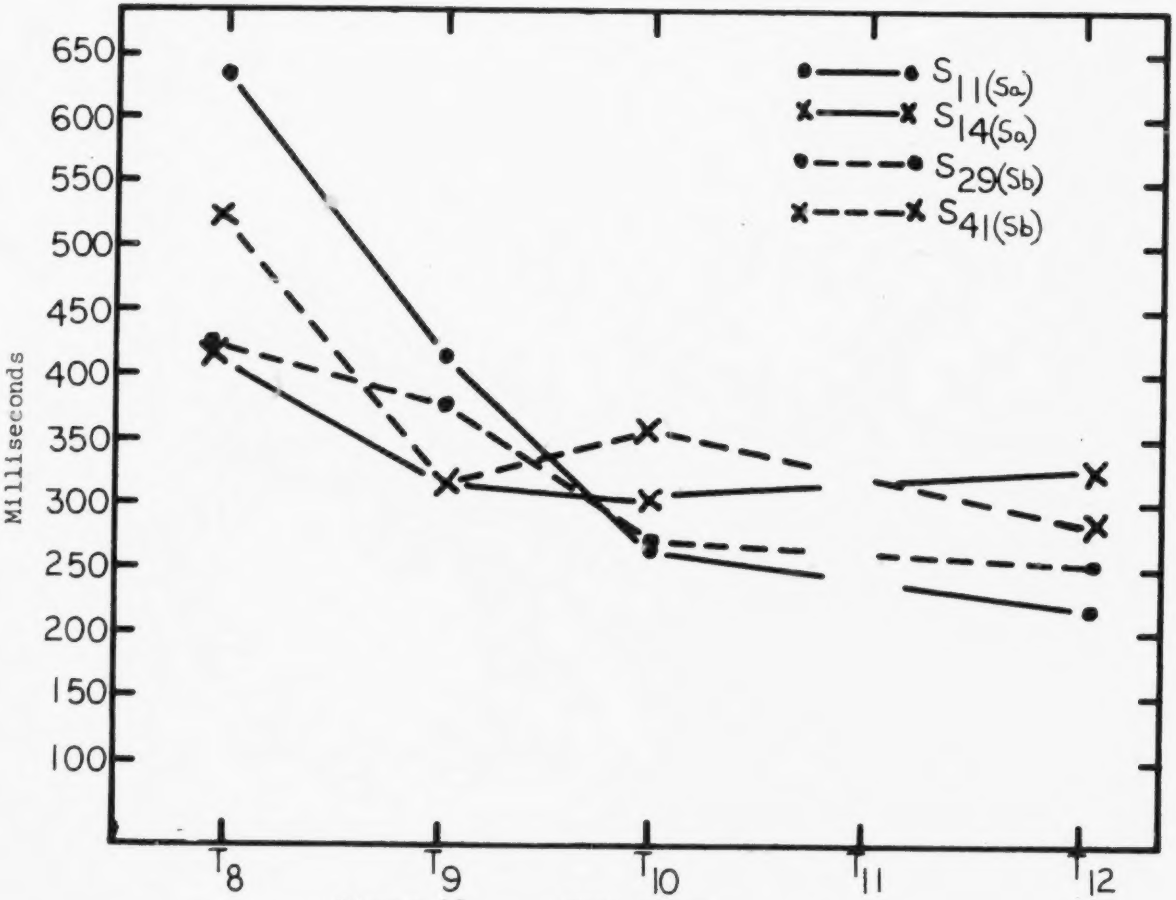

650
600
550
500
450
400
350
300
250
200
150
100
Milliseconds
$S_{11}(Sa)$
$S_{14}(Sa)$
$S_{29}(Sb)$
$S_{41}(Sb)$
T_8
T_9
T_{10}
T_{11}
T_{12}
Test Times

Figure 40.

Figure 41 displays the mean duration for two Suvag A and two Suvag B subjects. The same trend is indicated that was indicated in Figure 40,that is, that most of the subjects demonstrate a shorter duration at T_{12} than at T_8.

Figure 42 displays the mean duration for two Suvag A and one Warren child. These three subjects were placed on the same graph because of the noticeable decrease in the duration of their vocalizations from T_7 through T_{12}.

Figure 43 displays the mean duration for four Warren children over the T_8 through T_{12} testing period. Once again there seems to be a decrease in duration over these testing times. Figure 44 displays the mean duration for two Warren children over the T_8 through T_{10} testing times. Both subjects show less of a duration at T_{10} than at T_8.

In conclusion, it appears that the therapy procedures and/or the amplification have had the effect of reducing the duration of the vocalizations of these children over the testing times. It suggests that the therapy procedures and/or the amplification are able to bring the durational patterns closer to that of a normal-hearing person and as a result would probably allow the child to produce more intelligible speech.

Figure 45 displays the mean duration of one subject for the four experimental conditions used in the 1-9 procedure. As can be observed, the duration decreases from T_7 through T_{12}. It appears that the condition with amplification (the solid line) in general provides a slightly greater duration that the conditions without amplification. Other than this, there does not appear to be any significant effect of the different experimental conditions on the duration of vocalizations.

The data presented in the second half of this chapter were only samples from some of the measurements which we are continuing to obtain on these children. As these data become available they will be analyzed statistically to determine any significant differences between the Suvag and the Warren groups.

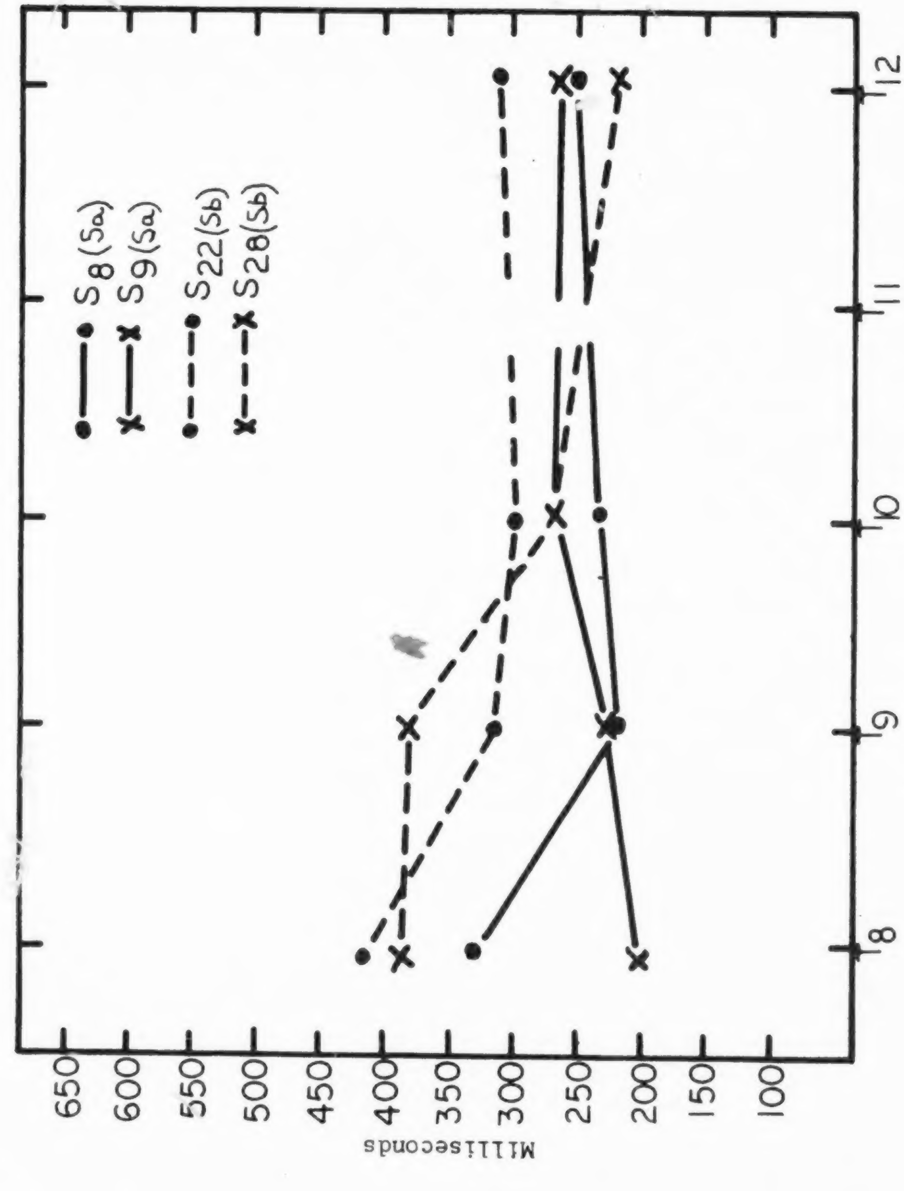


Figure 41. Test Times

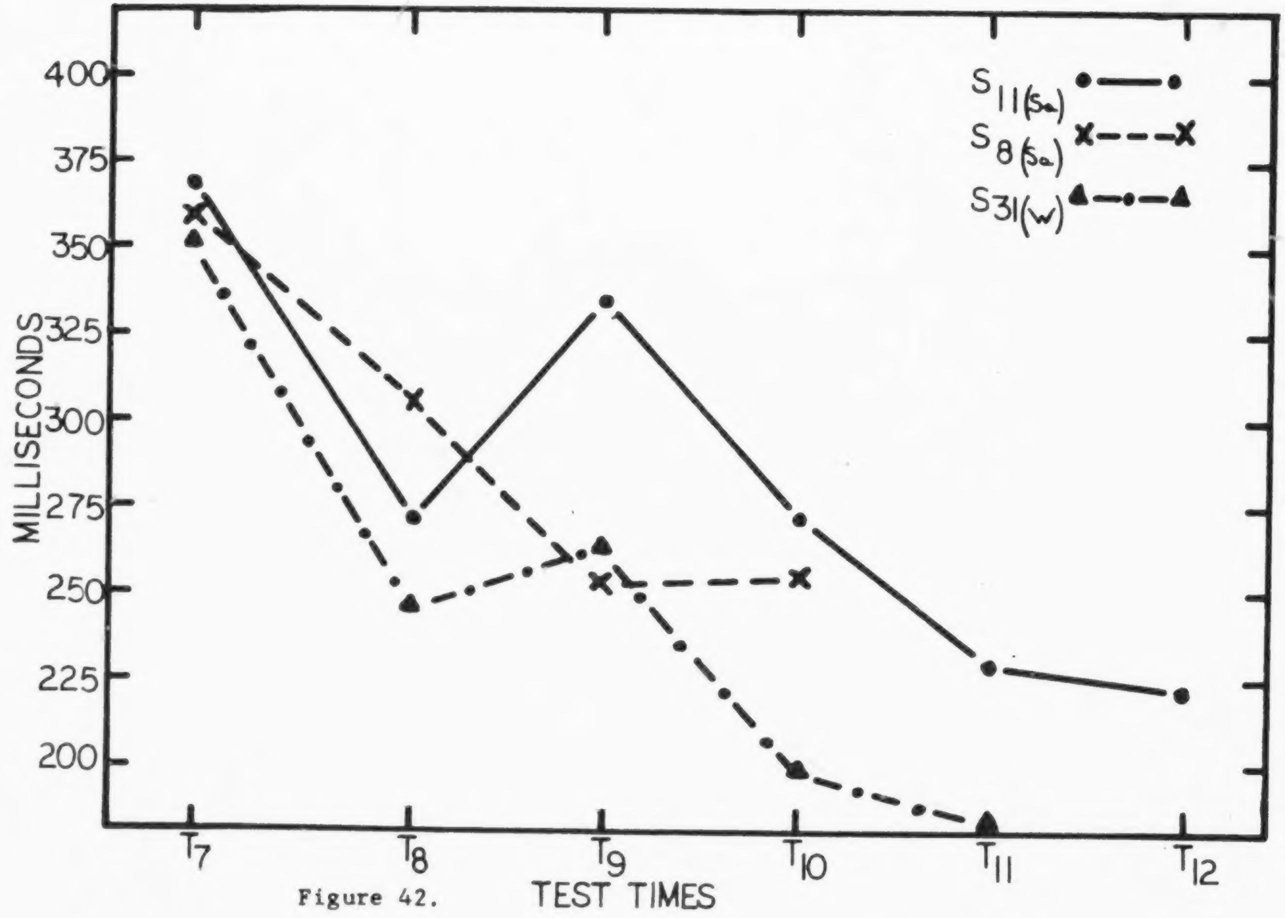

MILLISECONDS
400
375
350
325
300
275
250
225
200
T_7
T_8
T_9
T_{10}
T_{11}
T_{12}
TEST TIMES
S_{11}(Sa)
S_8(Sa)
S_{31}(W)

Figure 42.

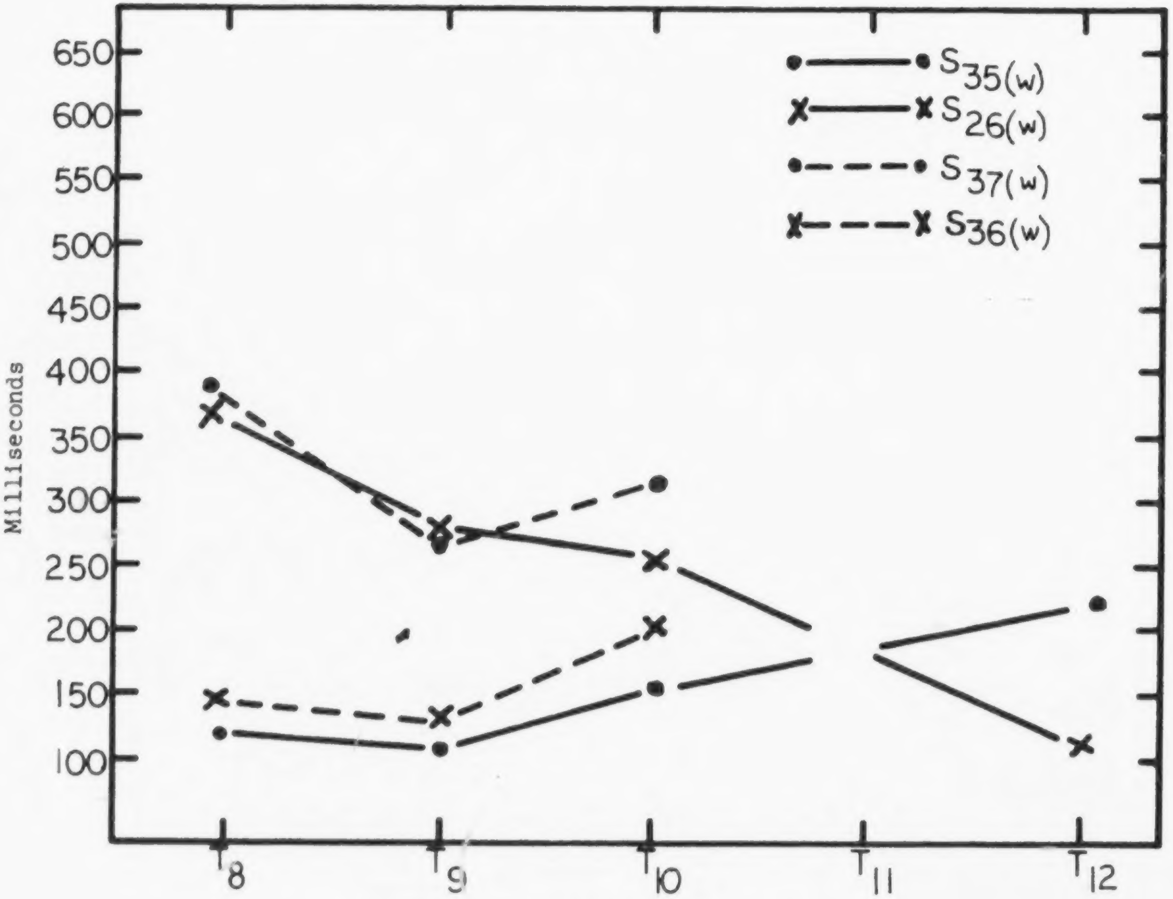

Milliseconds
650
600
550
500
450
400
350
300
250
200
150
100
$S_{35(w)}$
$S_{26(w)}$
$S_{37(w)}$
$S_{36(w)}$
T_8
T_9
T_{10}
T_{11}
T_{12}
Test Times

Figure 43.

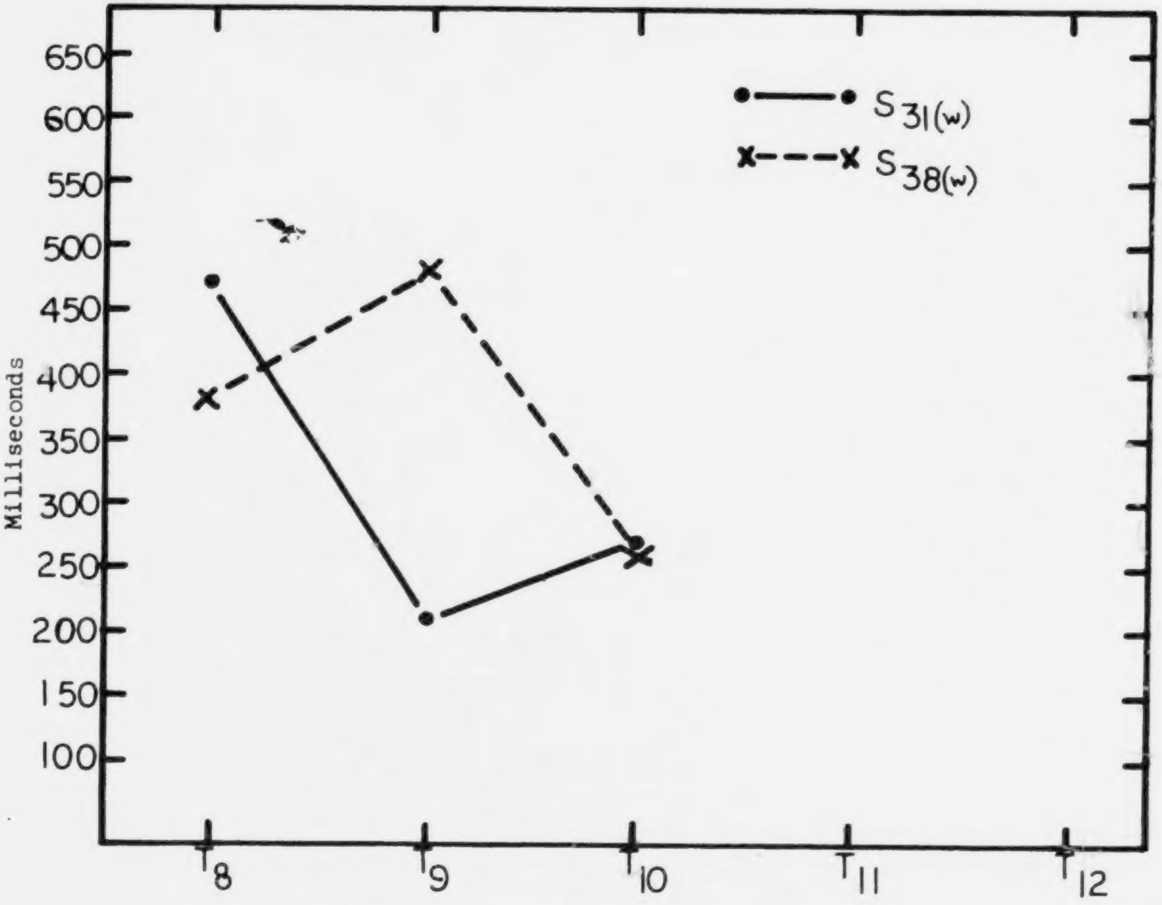

S31(w)
S38(w)
Milliseconds
650
600
550
500
450
400
350
300
250
200
150
100
T8
T9
T10
T11
T12
Test Times

Figure 44.

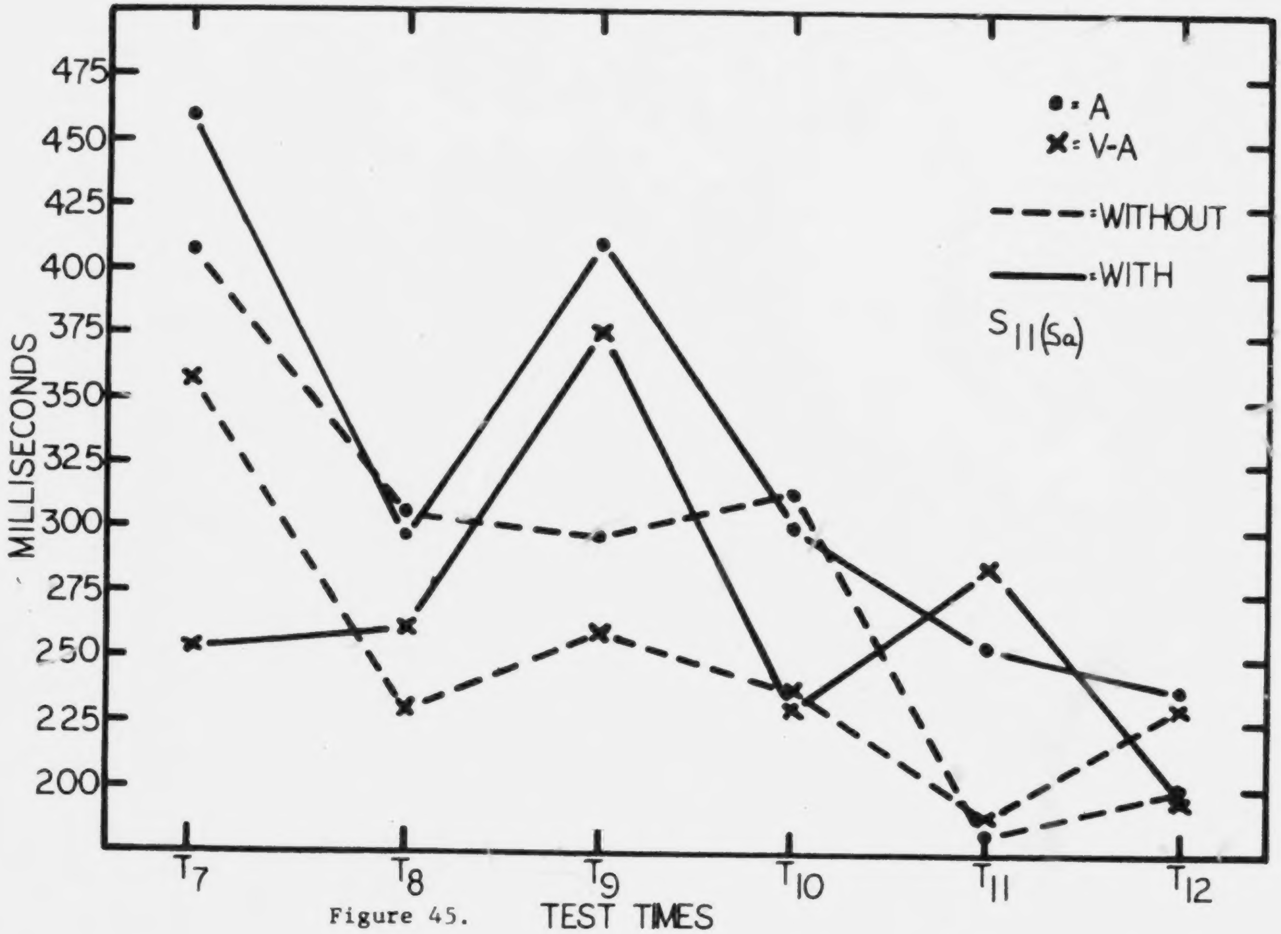

475
450
425
400
375
350
325
300
275
250
225
200
MILLISECONDS
T7
T8
T9
T10
T11
T12
TEST TIMES
● = A
✖ = V-A
- - - = WITHOUT
—— = WITH
S11(Sa)

Figure 45.

CHAPTER V
FUNDAMENTAL FREQUENCY

Andrew Stewart, M.A.

As indicated in the previous chapter, observers who visit our program usually comment that our children have good voice quality rather than the typical high-pitched voice that is usually associated with deaf speakers. One way of evaluating the validity of these observations is to measure the fundamental frequency. These measures can be utilized to compare children that are assigned to either Suvag or Warren units. The following is the experimental procedure and a discussion of some measures that have been analyzed.

Procedure

The Trans Pitchmeter (a fundamental frequency-locating unit) and a new instrument being developed in the University of Tennessee Speech Science laboratory for the same purpose are fully described in Chapter 9. Therefore, the following explanation of the method employed in the measurement of fundamental frequency presupposes an understanding of the Trans Pitchmeter and provides no further explanation of it.

The original procedure, as utilized during summer, 1971, involved directing live voice speech stimuli (usually /ə/ to the Trans Pitchmeter and then displaying the fundamental frequency output as a sawtooth waveform on a storage oscilloscope. The time base amplifier of the scope was adjusted so that, by counting the number of spikes displayed across the entire width of the screen, the investigator could accurately determine the fundamental frequency of the input signal.

The subsequent procedure, as utilized up to the present time, involves directing recorded speech samples (words) from a tape recorder through a high-pass filter to reduce low-frequency noise and into the Trans Pitchmeter. The fundamental frequency output of the Trans Pitchmeter is displayed as a sawtooth intonational pattern on the screen of a storage oscilloscope, with changes in fundamental frequency being reflected by variations in level of the display. The stored display on the screen is inverted so that levels at the top of the screen indicate a low fundamental frequency and levels at the bottom of the screen indicate a higher fundamental frequency. The screen is calibrated with internal calibration tones of the Trans Pitchmeter that range from 160 Hz to 500 Hz. The calibration of the tones is checked for accuracy with an electronic frequency counter. Changes in fundamental frequency are read on the screen at 40 millisecond (msec) intervals over the entire duration of the signal, and these measurements are used to obtain the mean fundamental frequency and the intonational pattern of each word.

Five subjects have been measured up to the present time: S8(Sa), S9(Sa), S11(Sa), S31(W), and S37(W). They were selected because they represented both types of amplification (Suvag and Warren), varying lengths of time in therapy, and varying degrees of hearing impairments. All subjects were measured from test time seven through test time twelve, if recorded speech material was available on them for each of these times. Although this report formally concerns only times seven, eight, and nine, some findings concerning times ten, eleven, and twelve will be included in order to better illustrate changes in fundamental frequency over time.

Four recorded words (or a consistent substitute for each) were used in the measurement of each subject's fundamental frequency. These words were lamb, baby, up, and sit. The recorded words were obtained from the same tape recordings that were used to measure the intelligibility of each child's speech (the 1-9 ratings, described above, on p 36). Each word was measured in all four of the experimental conditions: auditory only without amplification, auditory and visual without amplification, auditory only with amplification, and auditory and visual with amplification. A mean fundamental frequency was then computed for each word for each child at each test time.

Results

The results obtained thus far will be stated in terms of expectations that we hold in regard to the fundamental frequency and the intonational pattern of pre-lingual deaf children trained with the Verbo-tonal Method.

In the first place, it seems reasonable to expect that a child's fundamental frequency will increase as a function of increasing degree of hearing impairment. Figure 46a (left side) and 46b (right side) display the mean fundamental frequency (ordinate axis) of the five subjects as a function of hearing loss in dB (abscissa) for time seven (T_7, left side of graph) and time eight (T_8, right side of graph). In general, fundamental frequency increases as hearing loss increases. It is interesting, also, to note that $S_{9(Sa)}$ who appeared to have a higher fundamental frequency than would be expected for her degree of hearing loss at T_7 began to decrease in fundamental frequency at T_8.

Furthermore, we would expect that a deaf child's fundamental frequency should decrease (to a "normal" level) as a function of an increasing amount of time spent in therapy, if indeed the low-frequency amplification used in therapy is aiding him to monitor his speech more effectively. Figure 47 shows the mean fundamental frequency of the five children as a function of testing time. Therapy hours increase from T_7 to T_{12}. Several points can be made about this Figure. It will be noted that the two Warren subjects, $S_{31(W)}$ and $S_{37(W)}$, showed little decrease in fundamental frequency; in fact $S_{31(W)}$, after an initial decrease, began to increase once again, perhaps indicating that the type of amplification he was receiving in therapy was not successfully aiding him to monitor his vocal production. $S_{37(W)}$ whose hearing level was about 50 dB in her better ear, exhibited a mean fundamental frequency that was well within the normal range for her age, and so no decrease would be expected in her case. Likewise, $S_{11(Sa)}$ showed little decrease; but again his fundamental frequency was low enough from the outset that no decrease was expected. $S_{8(Sa)}$, a child with a severe hearing loss, showed a dramatic decrease in fundamental frequency over time; in fact, since she began therapy at time one, prior to the grant, it is possible that her fundamental frequency had dropped even more than this figure illustrates. $S_{9(Sa)}$ was measured over only three times because of poor signal-to-noise conditions in her recording for T_{10} through T_{12}. However, her better-ear hearing loss was only moderate, and she showed improvement in all other areas of therapy; and so it is reasonable to assume that she improved in the vocal parameter of fundamental frequency as well.

Another hypothesis that could be made is that a deaf child's fundamental frequency should decrease as a function of decreasing 1-9 scale value indicating an increase in intelligibility of vocal production. Figure 48 displays the mean fundamental frequency of the five subjects as a function of the 1-9 scale

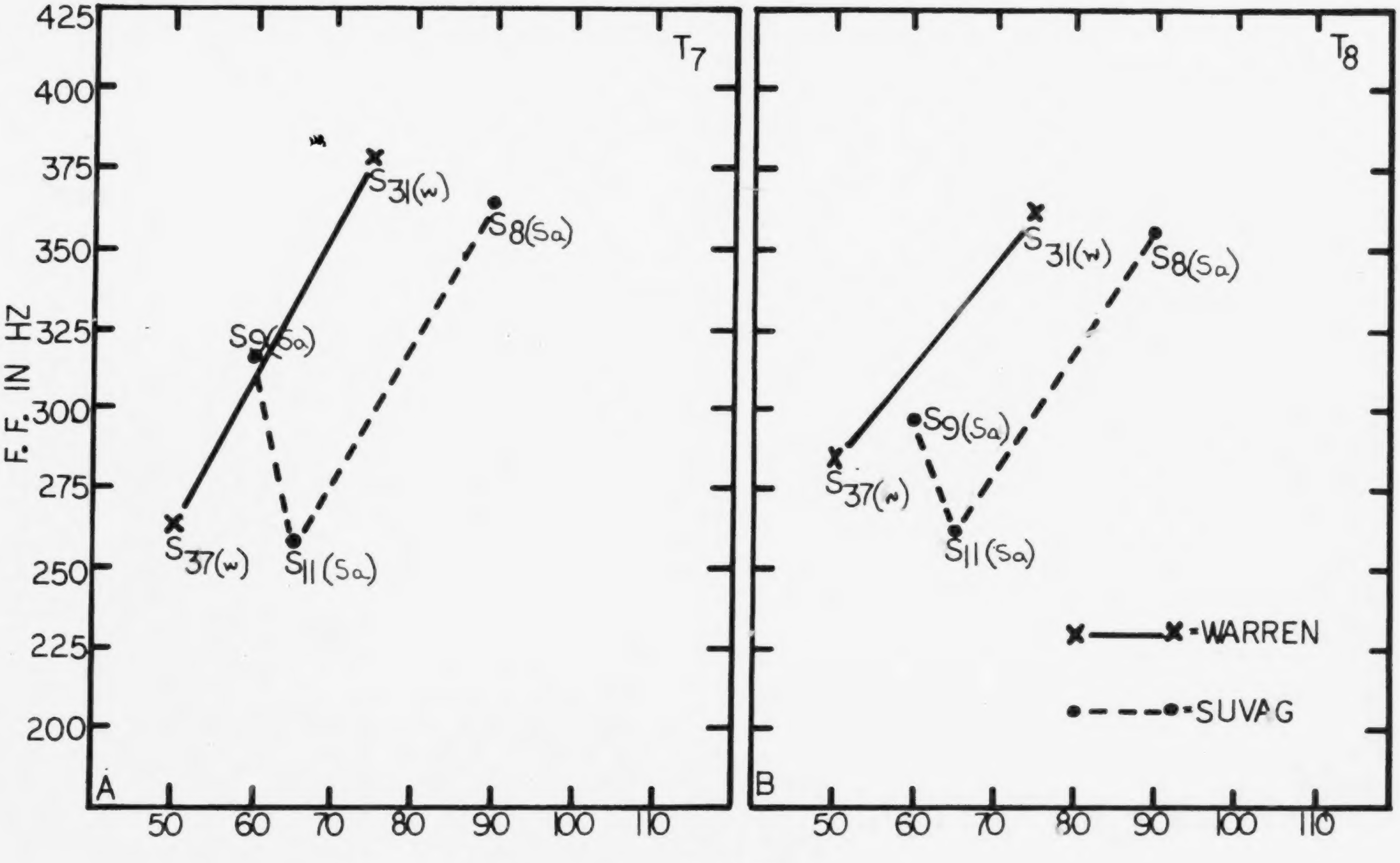

F. F. IN HZ
425
400
375
350
325
300
275
250
225
200
A
B
T7
T8
S31(w)
S8(Sa)
S9(Sa)
S37(w)
S11(Sa)
50
60
70
80
90
100
110
X——X-WARREN
●- - -●-SUVAG
dB HTL

Figure 46.

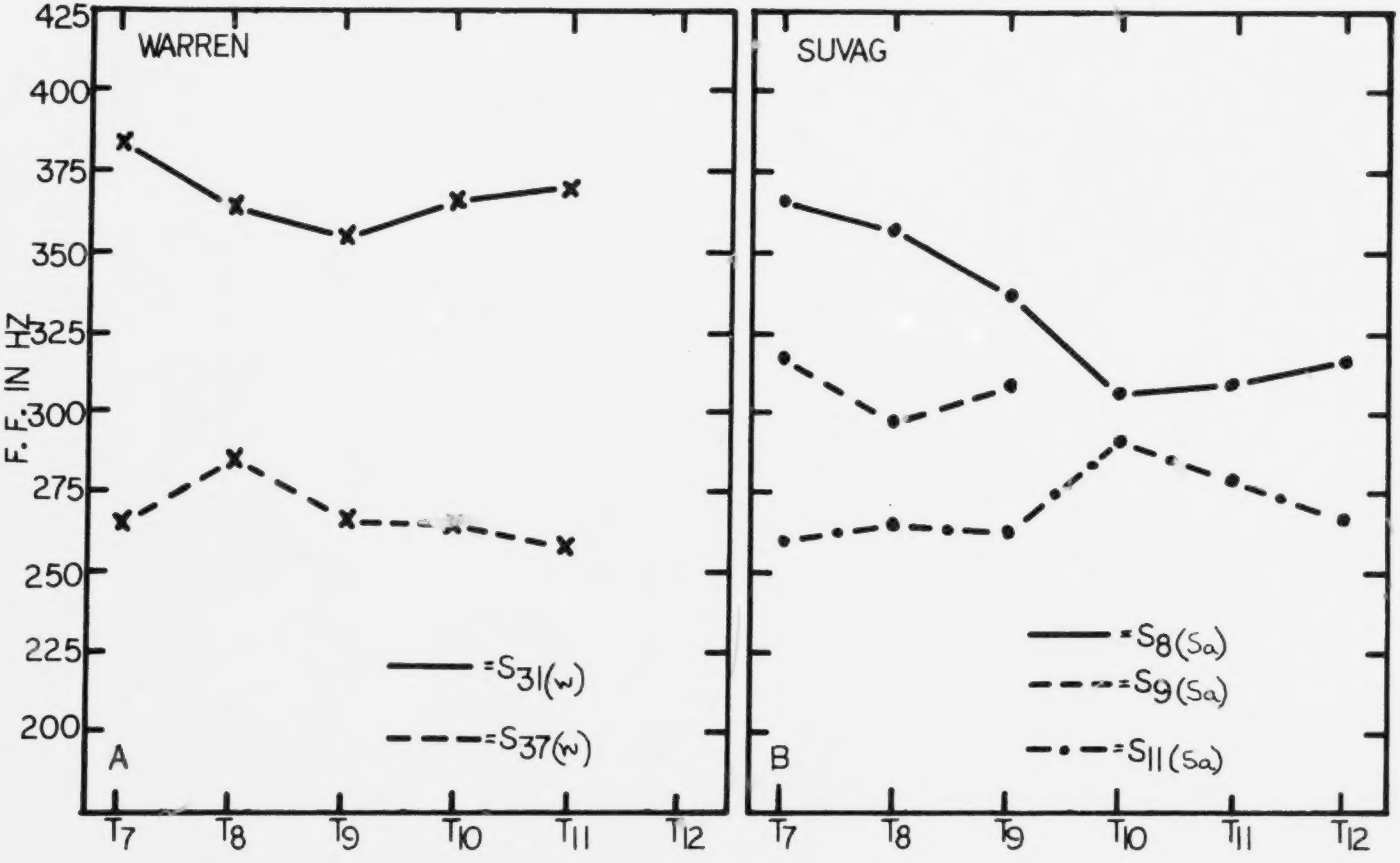

WARREN
SUVAG
A
B
425
400
375
350
325
300
275
250
225
200
F. F. IN HZ
T7
T8
T9
T10
T11
T12
=S31(w)
=S37(w)
=S8(Sa)
=S9(Sa)
=S11(Sa)
TEST TIMES

Figure 47.

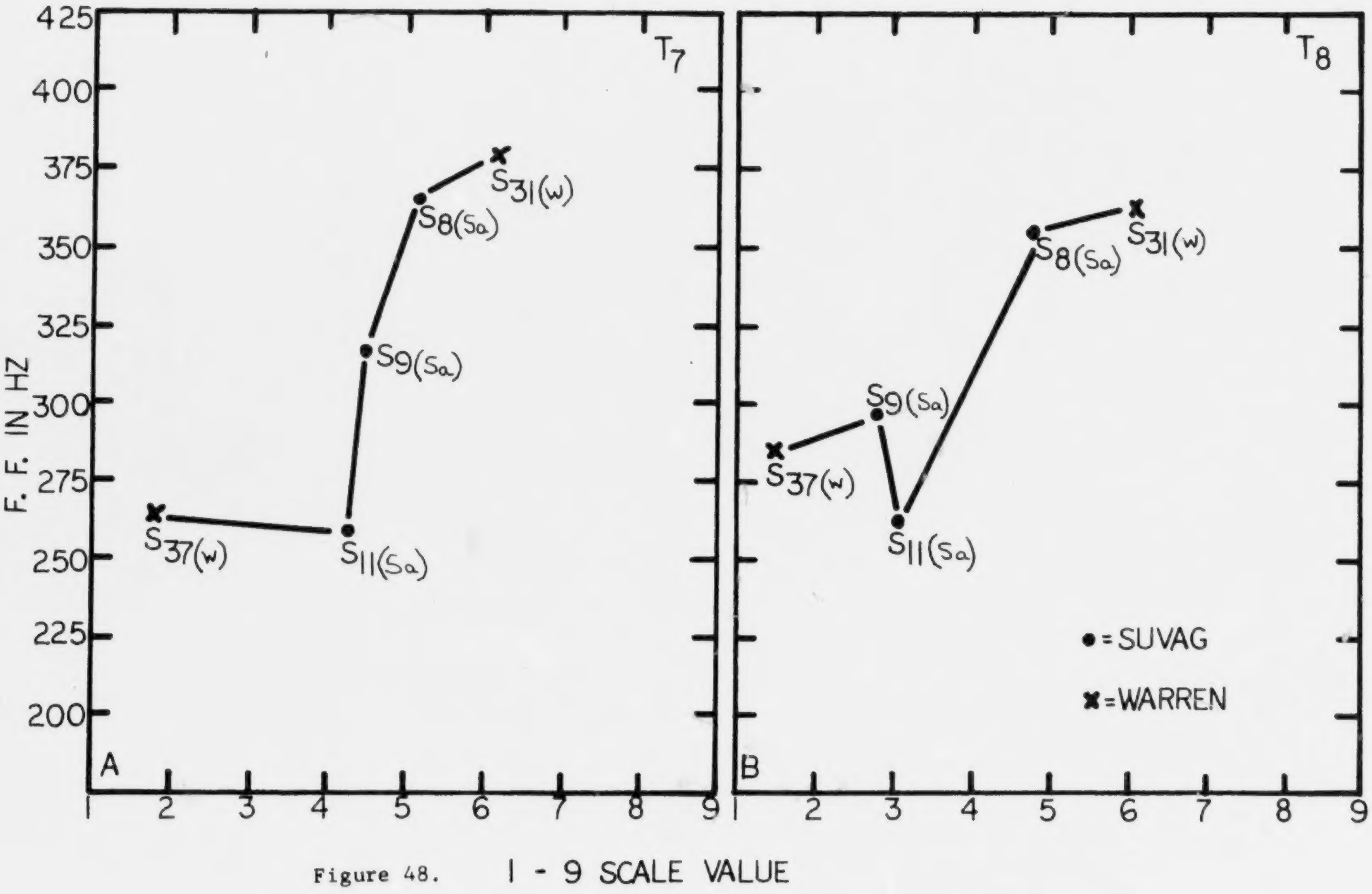
425
400
375
350
325
300
275
250
225
200
F. F. IN HZ
A
T7
S_{37}(w)
S_{11}(Sa)
S_9(Sa)
S_8(Sa)
S_{31}(w)
B
T8
S_{37}(w)
S_9(Sa)
S_{11}(Sa)
S_8(Sa)
S_{31}(w)
● = SUVAG
✖ = WARREN
1
2
3
4
5
6
7
8
9
1 - 9 SCALE VALUE

Figure 48.

value achieved for T_7 and T_8. It will be observed that, in general, fundamental frequency does appear to decrease as intelligibility increases. This is longitudinally noticeable in $S_{9(Sa)}$, but the effect is much more striking when the entire group of five subjects is considered cross-sectionally at each testing time.

A fourth expectation that could be generated is that the subjects' intonational patterns (fundamental frequency variation over the duration of a vocal production) should more closely approximate a normal intonational pattern as a function of increasing time spent in therapy. Figures 49 through 52 display the intonational patterns of three subjects for the word "baby" at an early time (T_7) and at a late testing time (T_9). The patterns are plotted in terms of the fundamental frequency measured every 40 milliseconds through the duration (abscissa) of the vocal production. In every case, the stimulus used for comparison (the "normal" intonational patterns referred to above) is that of the teacher who recorded all of the subject's vocal productions. The word "baby" was chosen because it provided enough duration to make intonational variations noticeable. The test condition chosen for measurement of the production of "baby" was auditory only with amplification(C1A2), for it was assumed that this condition provided the most representative example of the subject's vocal capabilities without the additional help of visual clues.

It will be noted that $S_{31(W)}$ (Figures 49 and 50) exhibited a marked degree of improvement in his intonational pattern from T_7 to T_8, approximating the stimulus more closely in both intonational and duration at T_8. It should be observed that the scale of the ordinate had to be changed in Figure 49 in order to accommodate the extremely-high frequencies of the subject's production.

$S_{37(W)}$ and $S_{8(Sa)}$ (Figures 51 and 52), on the other hand, showed less improvement over time, although $S_{8(Sa)}$ did shorten the duration of her production at T_9. However, the overall range of her production decreased at T_9 (see Table 23). $S_{37(W)}$ showed an intonational pattern rather similar to that of the stimulus at T_7, and so we would not expect an improvement at T_9; in fact, a slight decrease in range was noted (see Table 23).

Table 23 contains the range of intonation at T_7 and T_9 of each of the five subjects measured, as well as the range of the stimulus' intonation. This table indicates that the range of intonation at T_9 approached that of the stimulus more closely than did the range at T_7, for two Suvag subjects and one Warren subject.

It is hoped that the reader has gained a perspective of the potential of measuring fundamental frequency. In future reports, additional measures will be available to be discussed.

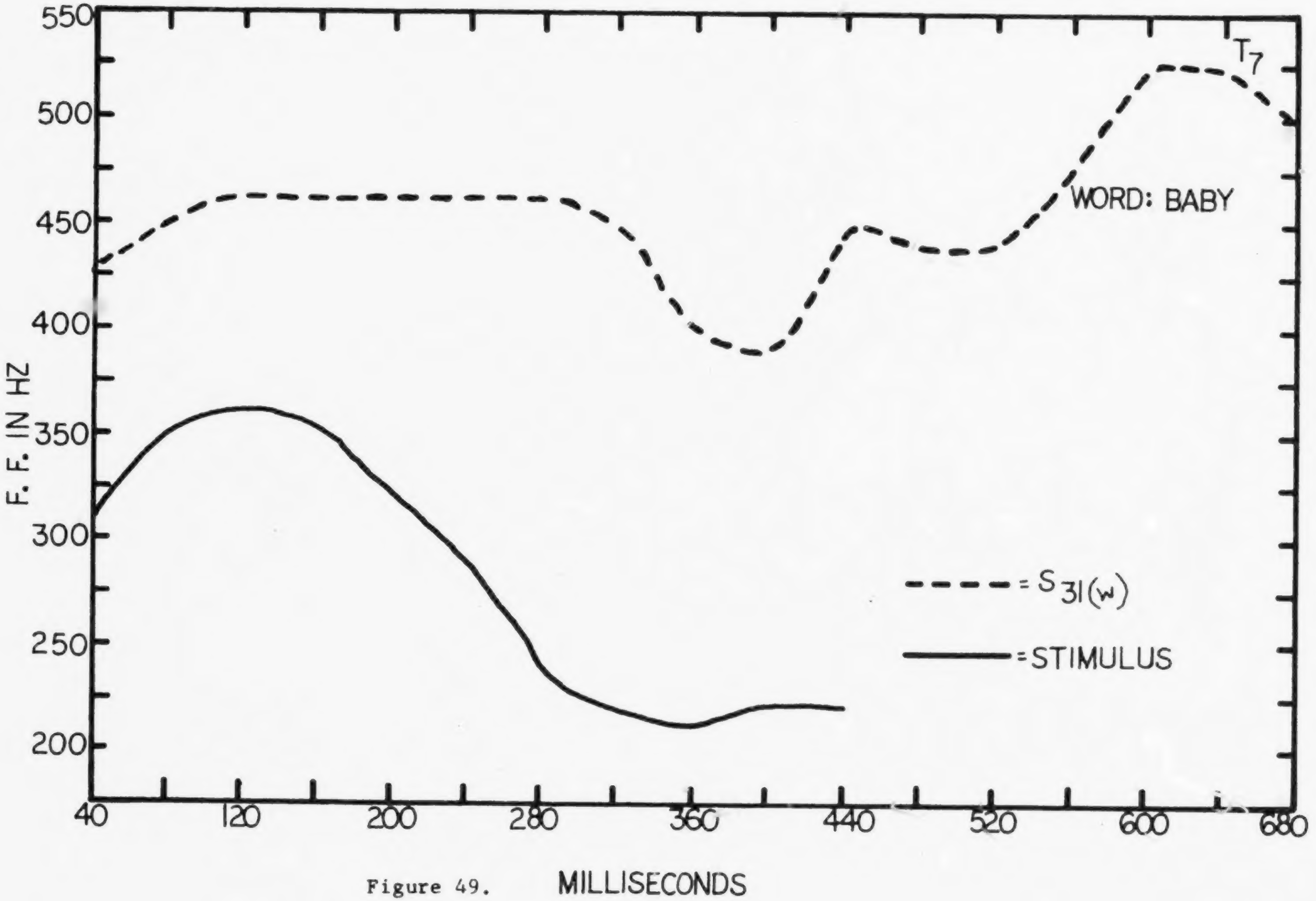

550
500
450
400
350
300
250
200
F. F. IN HZ
40
120
200
280
360
440
520
600
680
MILLISECONDS
T7
WORD: BABY
= S31(w)
= STIMULUS

Figure 49.

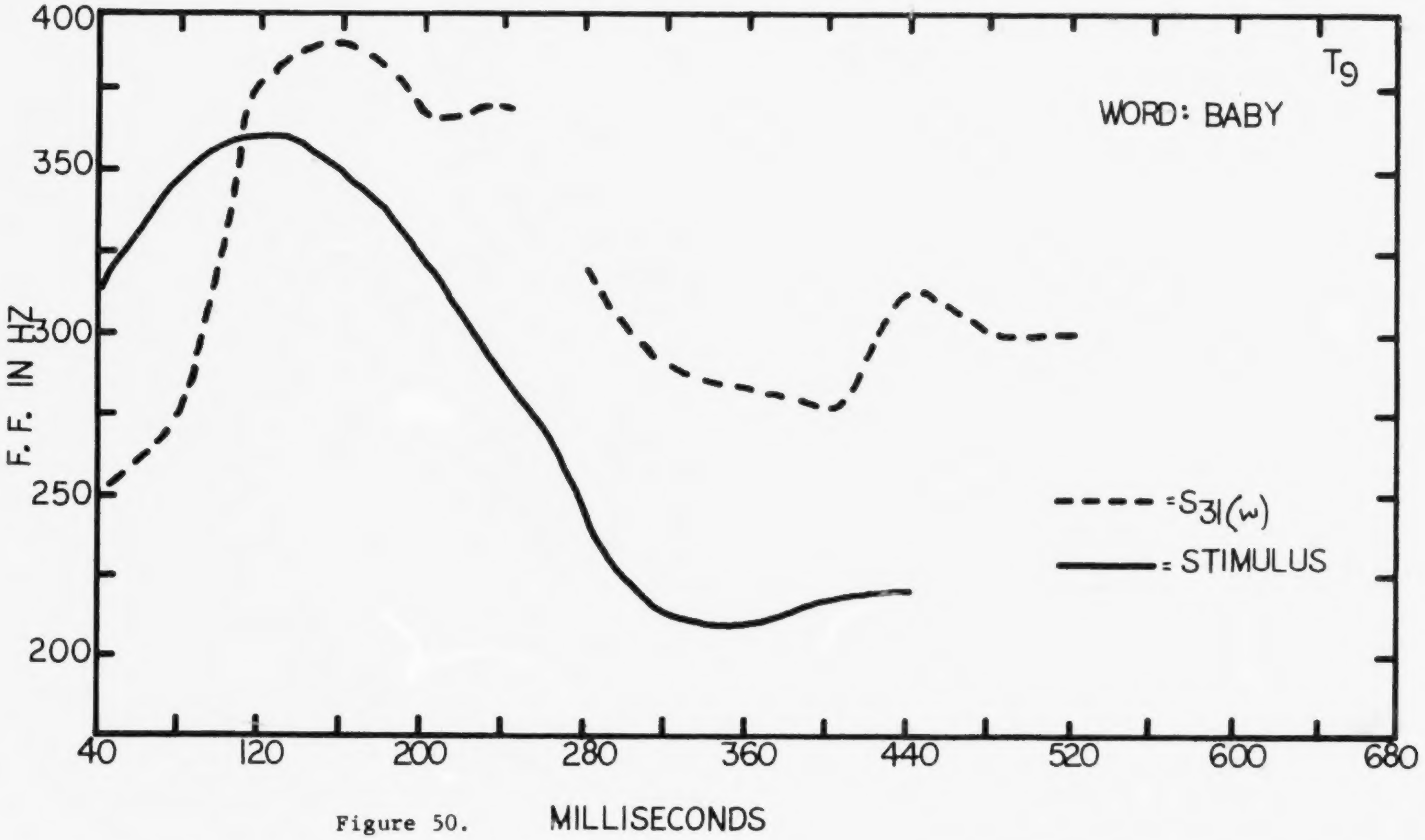

T9
WORD: BABY
F. F. IN HZ
400
350
300
250
200
40
120
200
280
360
440
520
600
680
MILLISECONDS
=S31(ω)
= STIMULUS

Figure 50.

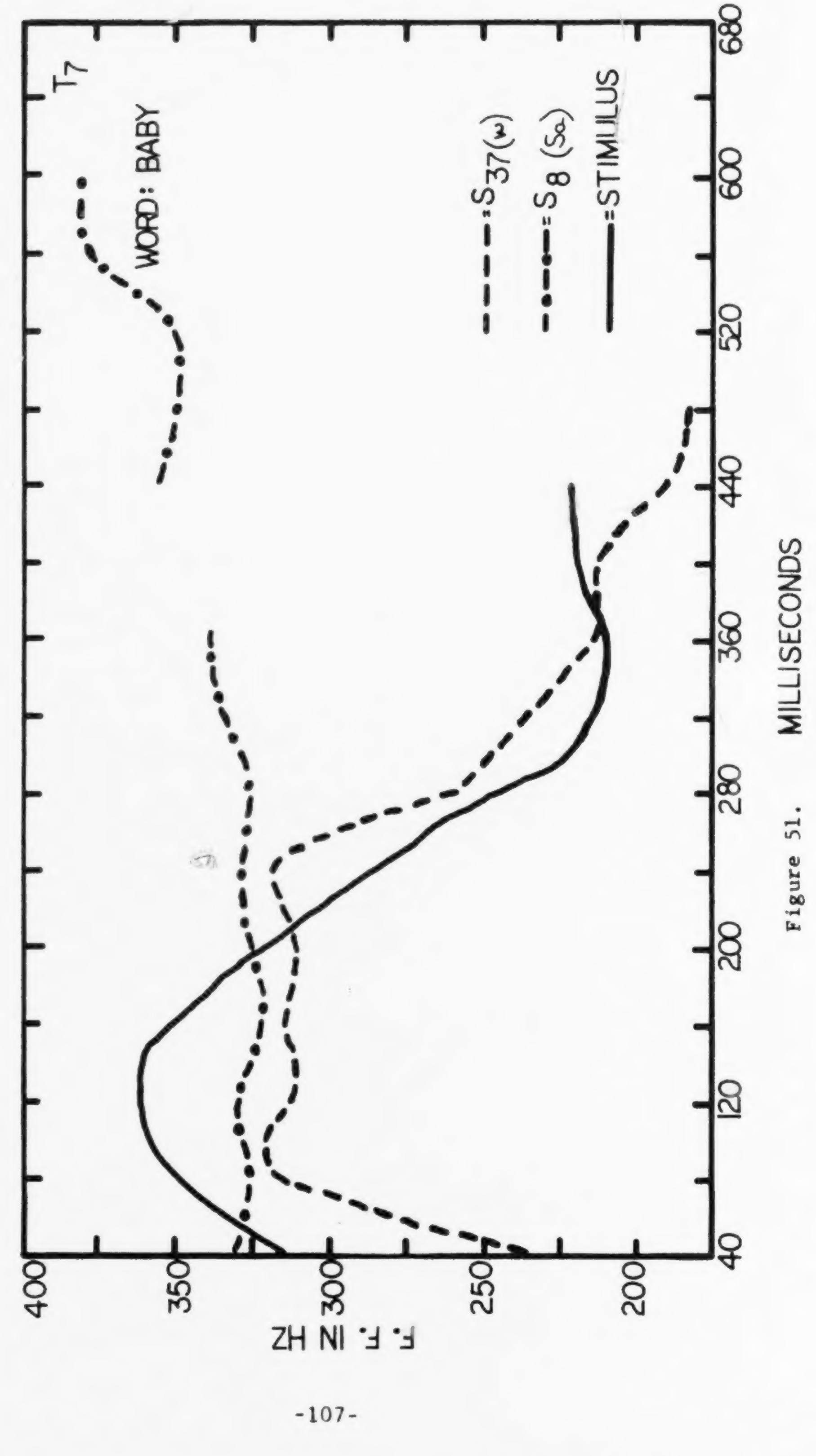

T7
WORD: BABY
S37(w)
S8 (Sa)
=STIMULUS
F. F. IN HZ
400
350
300
250
200
MILLISECONDS
40
120
200
280
360
440
520
600
680

Figure 51.

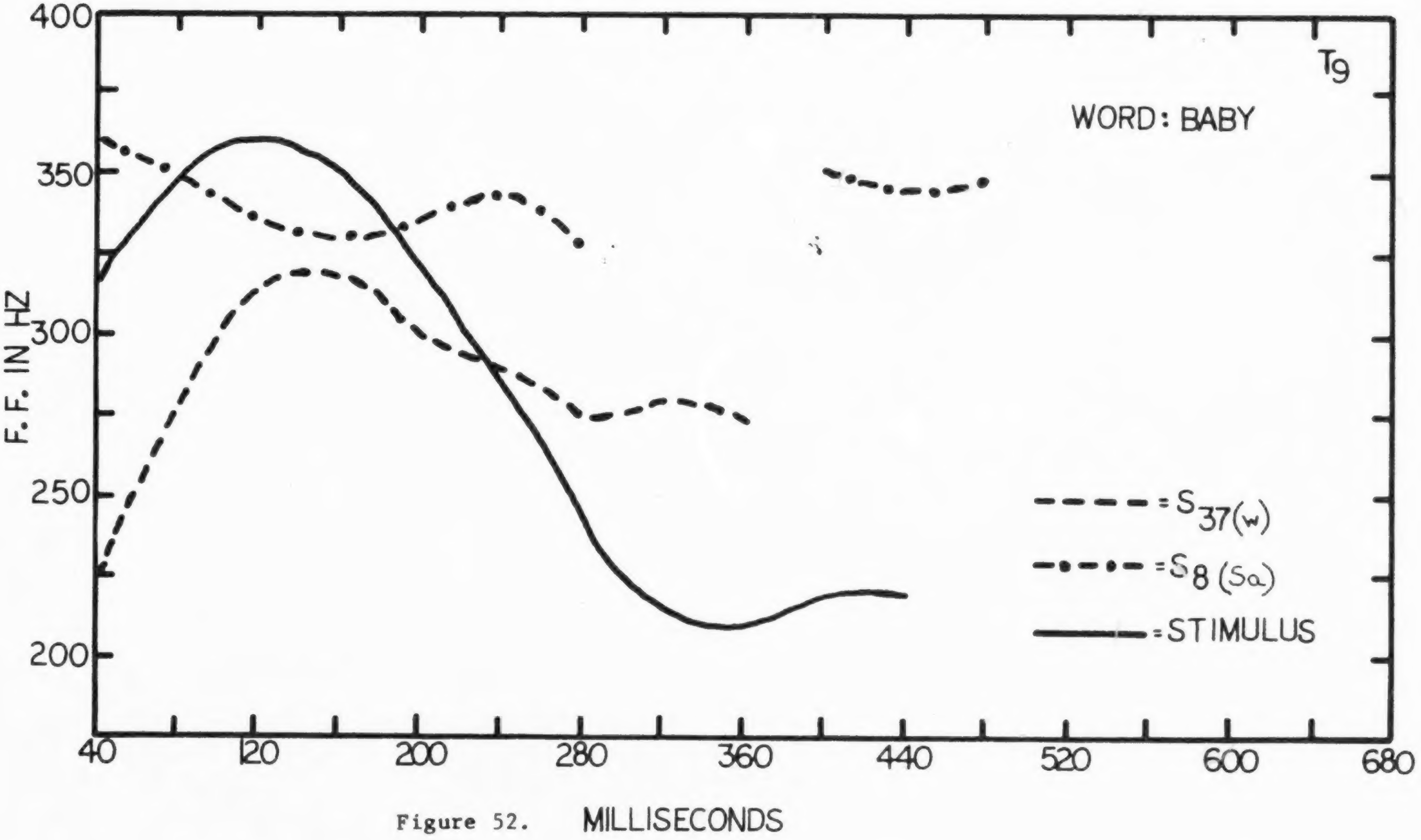

T9
WORD: BABY
F. F. IN HZ
400
350
300
250
200
40
120
200
280
360
440
520
600
680
MILLISECONDS
=S_{37}(w)
=S_8 (Sa)
=STIMULUS

Figure 52.

TABLE 23

RANGE OF INTONATION IN FREQUENCY (Hz) FOR FIVE SUBJECTS AS COMPARED WITH THE STIMULUS

RANGE OF INTONATION

Subjects	Word	Range of Intonation in Frequency (Hz)		
		Stimulus	T_7 Response	T_9 Response
S_8(Sa)	BABY	150	60	35
S_9(Sa)	BABY	150	75	190
S_{11}(Sa)	BABY	150	65	120
S_{31}(w)	BABY	150	135	140
S_{37}(w)	BABY	150	135	100
MEAN			94	117

CHAPTER VI
VERBO-TONAL AUDIOMETRY AND HEARING AID USAGE

Dianne R. Vertes, M.A.

In Chapter I of this report, the major aims of the original proposal were listed. One of these aims (number four) is to evaluate Verbo-tonal audiometry. One way to evaluate it is to compare the detection thresholds of filtered-speech testing to the thresholds of conventional pure-tone audiometry. The Project Audiologist was assigned this responsibility. In addition, the audiologist has the following responsibilities: (1) test each preschool deaf child and recommend an assignment to either Suvag or Warren amplification, so the groups would be similar in hearing level; (2) obtain reliable audiograms by a test and re-test procedure; (3) complete hearing and evaluations on each child and assign the Mini-Suvag or Zenith Vocalizer II; (4) monitor and evaluate hearing aid usage; (5) utilize other Verbo-tonal audiometric tests, e.g., non-filtered, whenever possible; and (6) develop additional audiometric measures for evaluating auditory perception.

Three different audiologists have assumed the responsibility of Project Audiologist. They are as follows: (1) Jane Madell, Ph.D., July 1, 1969 to September 1, 1970; (2) Mary McClanahan Peterson, M.A., January, 1971 to September, 1971; and (3) Dianne Vertes, M.A., September 1, 1971 to the present time. Throughout this time Mr. Jack Ferrell, M.A., clinical audiologist at the U.T. Hearing and Speech Center, has served as consultant and assisted the Project Audiologist whenever it was necessary. It should also be noted that Todd Porter, M.A., a graduate from our department, completed a thesis on Verbo-tonal audiometry. An abstract of this thesis can be viewed in Chapter X.

For this Interim Report, Miss Dianne Vertes, M.A., the present Project Audiologist, will report on the audiometric data she has obtained and relate these measures to some of the previous measures. The following has been written by Miss Vertes.

Pure-Tone Testing

All children in the program are tested at least three times each year. This is done in order to monitor any change in hearing acuity and to obtain reliable detection thresholds. Earlier in Chapter II, reference was made to the audiograms of twenty-five subjects included in this study. These audiograms are displayed in Appendices A, B, and C. All threshold levels are reported in ISO hearing levels (HL) and will be reported with this reference unless otherwise indicated.

It has been found that several children in the program have recurrent otitis media. The reports of parents and teachers relative to decreased acuity and perception have been found to be quite reliable. These children have been tested much more frequently and appropriate referrals have been made to local otologists. In addition, the babies in the program are seen on a weekly basis, for conditioning and repeat testing.

In one instance, a decrease in hearing was detected which was secondary to improper hearing aid usage. The child and her parents were instructed as to the proper volume setting and the child's hearing was checked repeatedly until it returned to previously obtained levels. Frequent testing also indicates the presence of fluctuating or progressive types of hearing loss.

Speech Testing (Conventional)

With the pre-lingually deaf child, speech testing is usually not accomplished, since speech discrimination ability is assumed to be zero percent. With the older children, where perception is present, speech discrimination testing will be initiated. Testing will utilize the PB-K test lists. There will be some initial testing to determine each child's familiarity with these words.

Verbo-Tonal Testing

A sample work sheet and Verbo-tonal audiogram may be seen in Table 24 and Figure 53. Logotomes (or nonsense syllables) are used as stimuli. These logotomes are identified in the lower right corner of Table 24. As can be seen from Table 24, Verbo-tonal audiometry encompasses several different auditory measurements. These include filtered logotomes, non-filtered logotomes, low transfer, high transfer and discontinuous transfer. Thresholds of detection and intelligibility can be obtained with each of the tests described above; however, unless otherwise indicated, the audiograms described below all represent detection measurements.

The rationale for Verbo-tonal audiometry is based on the concept of "optimal octaves." The optimal octave is the frequency band (Hz) that is optimal for the detection of each phoneme. For each logotome, the consonant and vowel have similar optimal octaves. For example, /mu-mu/ is a combination of a low-frequency (Hz) consonant and vowel, whereas /si-si/ is a combination of high frequency phonemes.

As may be seen in Figure 53, each logotome is associated with a particular frequency band. This arrangement indicates the presentation of logotomes for the optimal detection (filtered) test. Each logotome is filtered through a particular octave band which is called its optimal octave. Optimal detection (non-filtered) testing utilizes the same logotomes (with the exception of /bu-bu/); however, the stimuli in this test are not filtered. Conventional symbols (x=left, O=right) are used for both optimal detection tests. Symbols are connected with a continuous line.

Tests of transfer all utilize the same principle. In low transfer, a high frequency logotome /si-si/ is presented through four low-frequency bands, 150-300 Hz through 600-1200 Hz. High transfer testing utilizes a low frequency logotome /vo-vo/ filtered through the high frequency bands 1200-2400 Hz through 6400-12,800 Hz. Symbols for these tests of transfer are the conventional x and O connected with dashed lines; arrows indicate the direction of transfer (< < = low transfer, > = high transfer).

In tests of low and high transfer, a logotome is filtered through an octave that is not optimal for it. This threshold is compared with the threshold of the logotome that is optimal for that particular band.

In discontinuous transfer testing, /si-si/ is presented simultaneously through two discrete bands, one low (150-300 Hz) and one high (6400-12,800 Hz). Asterisk symbols (*) are used to indicate threshold for discontinuous transfer.

Filtered (optimal) detection thresholds are obtained for each child at least 3 times per year. Comparisons are made between Verbo-tonal and pure-tone thresholds. A discussion of these relationships may be found in the

TABLE 24

VERBO-TONAL TESTING

Name ______________________________

Optimal Detection

1B ____________

2A ____________

3A ____________

4A ____________

5A ____________

6A ____________

7A ____________

8A ____________

8B ____________

Low Transfer

2A ____________

3A ____________

4A ____________

5A ____________

High Transfer

6A ____________

7A ____________

8A ____________

8B ____________

Discontinuous Transfer

3A + 8B ____________

Non-filtered Detection

bru-bru ____________

mu-mu ____________

vo-vo ____________

la-la ____________

ke-ke ____________

shi-shi ____________

si-si ____________

VERBO-TONAL AUDIOGRAM

Name ____________________ Test ____________________

Date ____________________

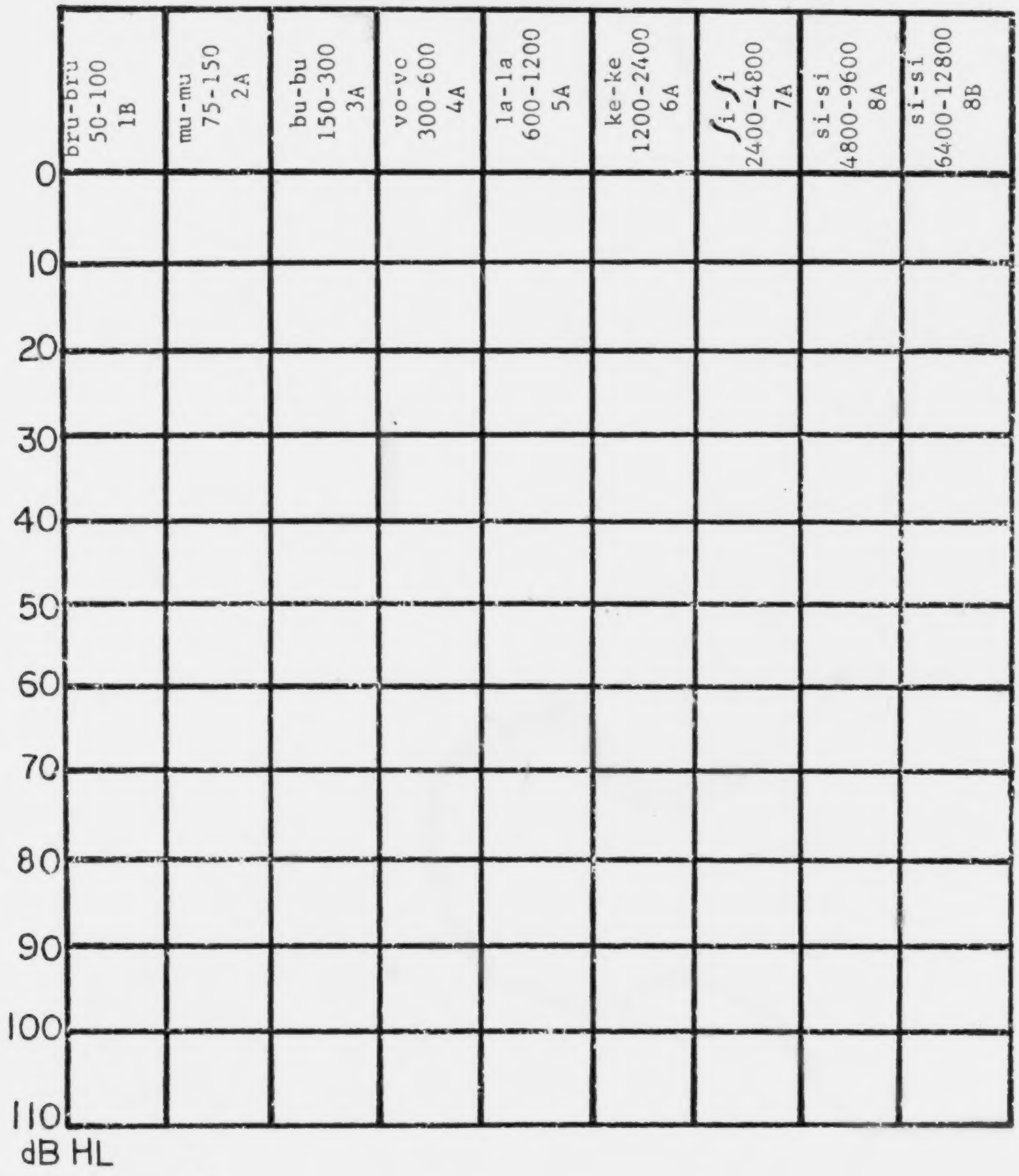


Figure 53.

calibration section in this chapter. Some difficulties have been noted with the Verbo-tonal audiometry. Primarily, the problems have been related to the speed with which the test can be administered. Since the attention span of the preschool children is generally limited, the validity and reliability of obtained results is dependent to a great extent on the rapidity with which the stimuli are presented. The stimuli are pre-recorded on audio tape and are presented through a Verbo-tonal audiometer which utilizes a Uher tape recorder. The advancing and re-winding of the tape to locate the proper stimuli is time-consuming. In order to increase reliability of results, an attempt will be made to devise a new equipment design which will allow the tester to switch very quickly from one recorded logotome to another.

An example of a typical Verbo-tonal audiogram may be seen in Figure 54. . This child's $S_{53}(S)$ pure-tone audiogram has also been included and may be seen in Figure 55 . As can be seen by comparing these two audiograms, the results are in good agreement from 1500 to 8000 Hz (1200-2400 Hz band through the 4800-9600 Hz band). The Verbo-tonal audiogram, however, shows better thresholds in the 6400-12800 Hz band. In addition, Verbo-tonal thresholds in the low frequencies (50-100 Hz through 300-600 Hz bands) indicate poorer hearing than the pure-tone test. On the basis of these discrepancies, repeat pure-tone testing was accomplished in order to rule out a possible conductive overlay.

It is quite important to constantly compare the Verbo-tonal audiogram with the pure-tone audiogram. Through such comparisons in the past, it was noted that some subjects were obtaining better thresholds in the high-filtered bands than would be expected based on pure-tone results. Further investigation indicated that this was due to added energy outside of the filter band caused by improper dubbing of the original audio tape. This situation was remedied by redubbing of the original using high quality Ampex tape recorders. In filtered speech testing, it is necessary to constantly evaluate the stimuli to determine if there is any acoustic energy outside of the filter band.

As another measure, thresholds of intelligibility might be obtained for some of the logotomes for both normal-hearing and hearing-impaired populations to determine the intensity differences between detection and discrimination thresholds. One might predict that the intensity level would have to be significantly increased in order for persons to discriminate the logotomes since they contain very little information and are low in redundancy. Also of interest would be to determine if this intensity difference varies as a function of the frequency (Hz) of the logotomes. Another point to consider is the improvement in intelligibility in thresholds as a result of therapy.

Calibration

For the first two fiscal years of the project, the calibration of Verbo-tonal audiometry was obtained by utilizing several normal-hearing listeners and computing the mean threshold for each filtered logotome. These mean detection levels of normal-hearing listeners were utilized as audiometric zero. The levels were obtained using the same Koss SP-3XC earphone and may be seen in Figure 56 (dated 3/71). The next three figures indicate levels in sound pressure level (SPL) and should not be confused with other Verbo-tonal audiograms where levels are indicated in terms of hearing level (HL).

VERBO-TONAL AUDIOGRAM

Name Cindy L. S53 (S) Test Optimal Detection(Filtered)

Date 2/11/72

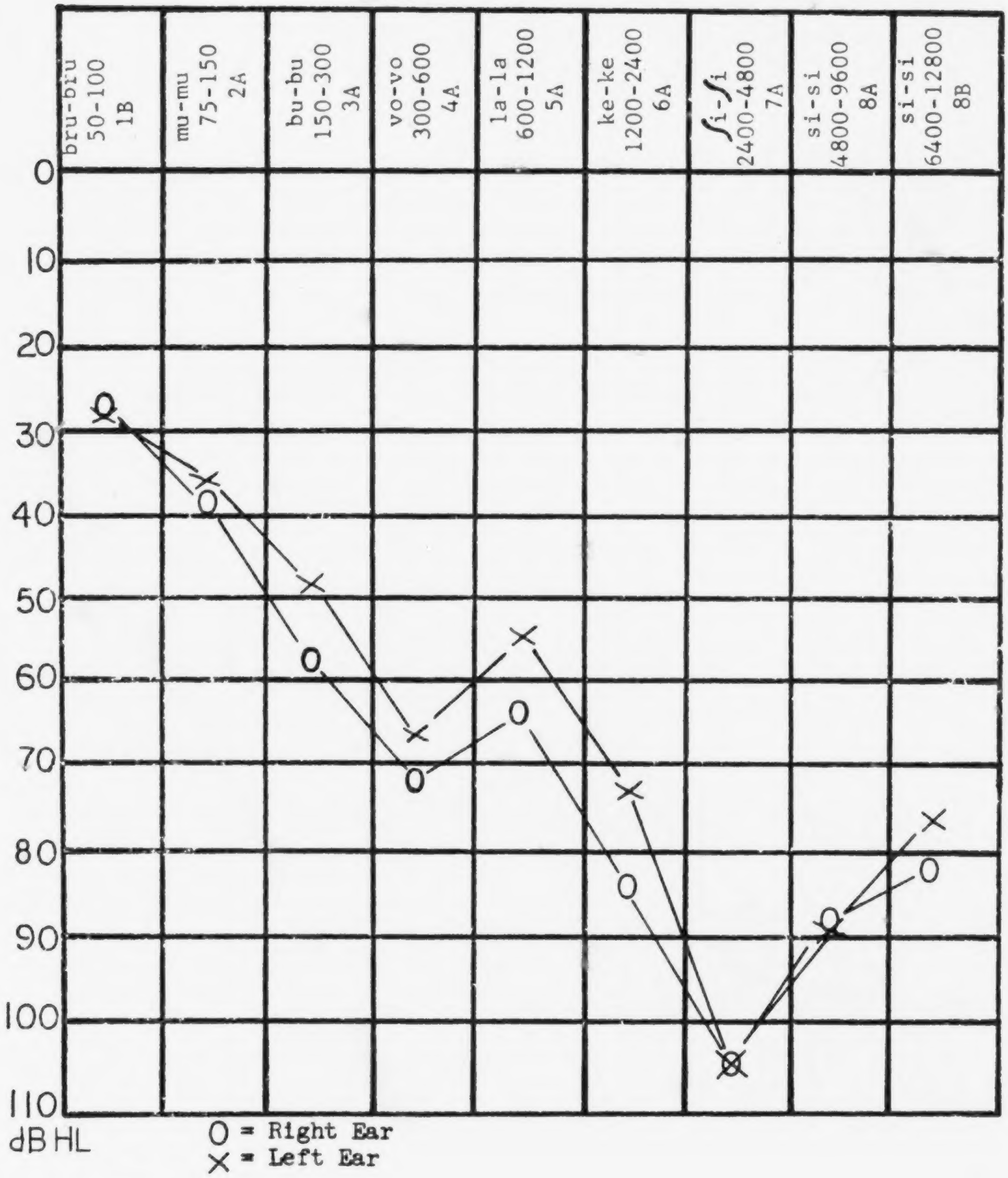


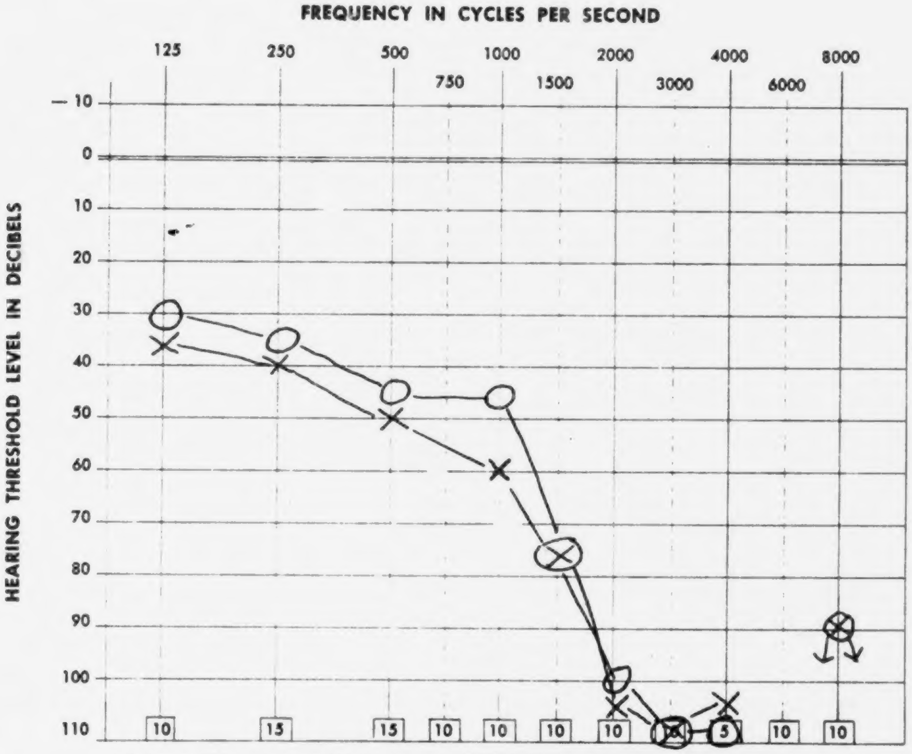
Figure 54.

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name C. L.; subject 53 (s) Date of Evaluation 10-1-71

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt 63 dB Lt 71 dB
2F AIR Rt 45 dB Lt 55 dB
125+250 RT. 32 dB Lt. 37 dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt ______ dB Lt ______ dB

FIELD: ______ dB

(ALL LEVELS RE NORMAL SRT)

Figure 55.

VERBO-TONAL AUDIOGRAM

Name Audiometric Zero Calibration Test Optimal Detection (Filtered)

Date 3/71

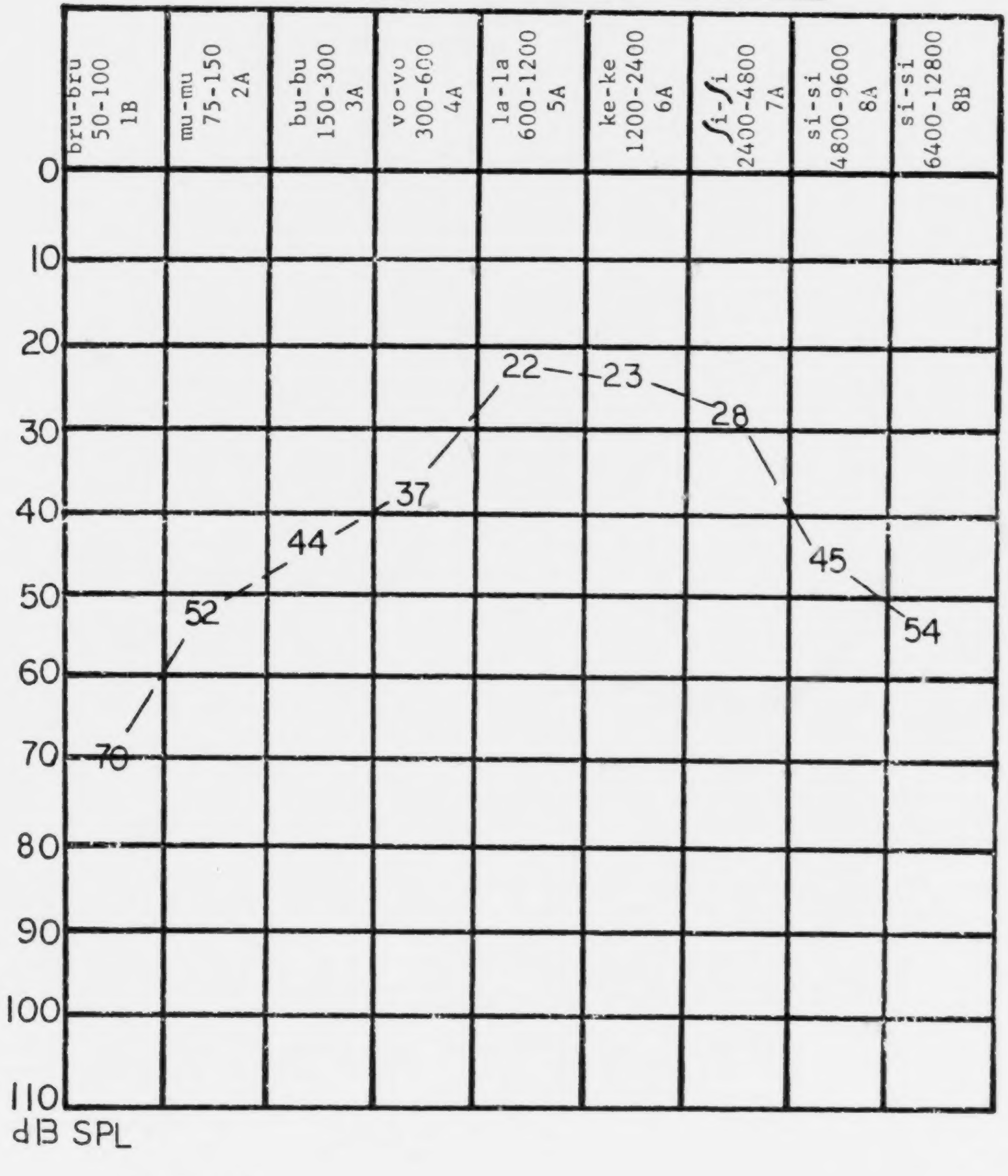


Figure 56.

The method of calibration now used is as follows. Pure-tone thresholds are obtained on one or two normal-hearing listeners. These values are changed in accordance with calibration correction factors (ISO-1964). These levels can then be matched with Verbo-tonal thresholds, to be obtained on the same listener or listeners. After Verbo-tonal optimal detection (filtered) thresholds are obtained in SPL, they are equated with the pure-tone thresholds. Each bandwidth is matched appropriately with a corresponding pure-tone frequency. Finally, all Verbo-tonal threshold levels are equated to audiometric zero, by correcting for any elevated thresholds in the individual listeners. An example of this process is as follows. If the pure-tone threshold at 1000 Hz is 10 dB, then a correction factor of 2 dB results in a corrected threshold of 8 dB. This threshold is equated with a Verbo-tonal threshold in SPL of 22 dB in the band 600-1200 Hz. This Verbo-tonal threshold is finally corrected to 0 dB HL by subtracting 8 dB, resulting in a Verbo-tonal audiometric zero threshold of 14 dB SPL. These values were obtained using the Koss K-6 earphone and may be seen in Figure 57.

The Koss K-6 earphones have been found to be quite linear, and are capable of 140 dB SPL output and seemed suitable for the children, since they wear them daily in the therapy situation.

A decision, however, was made to utilize the TDH-39 earphones with the MX 41/AR cushion. The 30 ohm set of TDH-39 was used in order to match the impedance output of the Verbo-tonal audiometer. The same manner of calibration was used (1-2 listeners) and the results may be found in Figure 58. As can be seen, responses at the two lowest bands 50-100 Hz and 75-150 Hz are considerably elevated in comparison with the K-6 responses. Since the K-6 earphones are circumaural, they provide a good acoustical seal which is important for the acoustic energy at low-frequencies. On the other hand, the TDH-39 phones do not have a good seal. This, then, is felt to be the cause of the elevation of thresholds in the low frequencies. Because of these elevated levels, there will probably be insufficient output in these bands to obtain threshold measurements with some of the children presently enrolled in our program. This,however, is not seen to be a disadvantage at this time. Since the same type of earphone is used for pure-tone testing and thus the same type of leakage is present, results of Verbo-tonal the pure-tone testing should be in better agreement than was evident in the past.

New Speech Tests

Several factors are evident in currently-available speech discrimination tests. One variable that is not under consideration in conventional testing is the frequency (Hz) of the words in the lists. Again, based on the 'optimal octave' concept, words have been classified according to their frequency in Hz. Thus, by combining two low-pitched phonemes /b/ and /u/, one can arrive at the low-frequency word "boo."

Although currently available word lists may be analyzed in this manner, the frequency (Hz) is not balanced within each 50 word list, nor is the frequency (Hz) constant from one list to another. These lists, then, are unsuitable if the variable under test is intensity as a function of frequency (Hz).

Discrimination testing in Zagreb, Yugoslavia is presently being accomplished using frequency (Hz) balanced word lists. Tests are utilized to obtain articulation curves for aided speech discrimination testing. It is felt that this type of discrimination testing gives a more complete picture of the function of the ear relative to intensity.

VERBO-TONAL AUDIOGRAM

Name Audiometric Zero Calibration Test Optimal Detection (Filtered)

Date 1/72

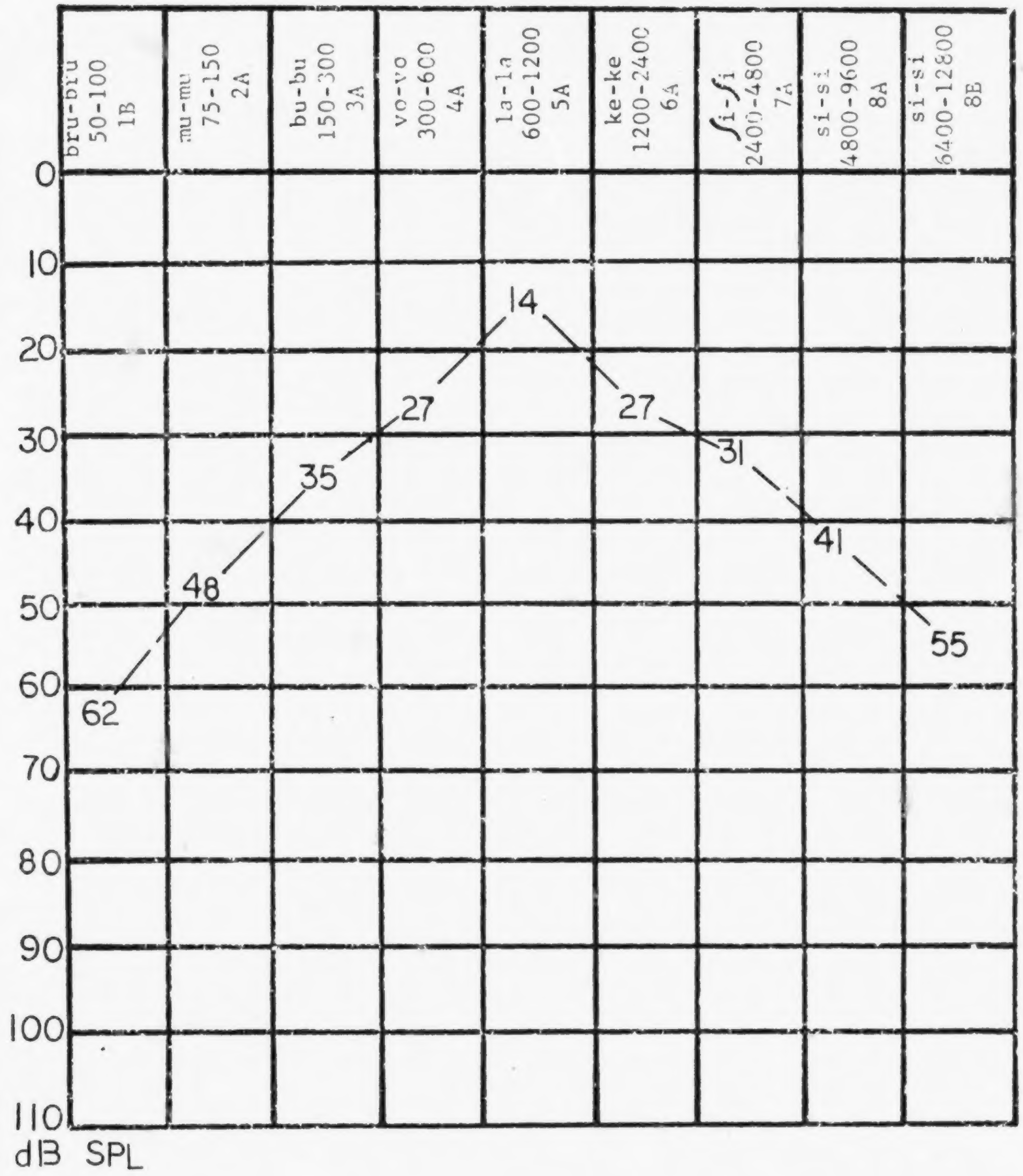


Figure 57.

VERBO-TONAL AUDIOGRAM

Name Audiometric Zero Calibration Test Optimal Detection (Filtered)

Date 2/72

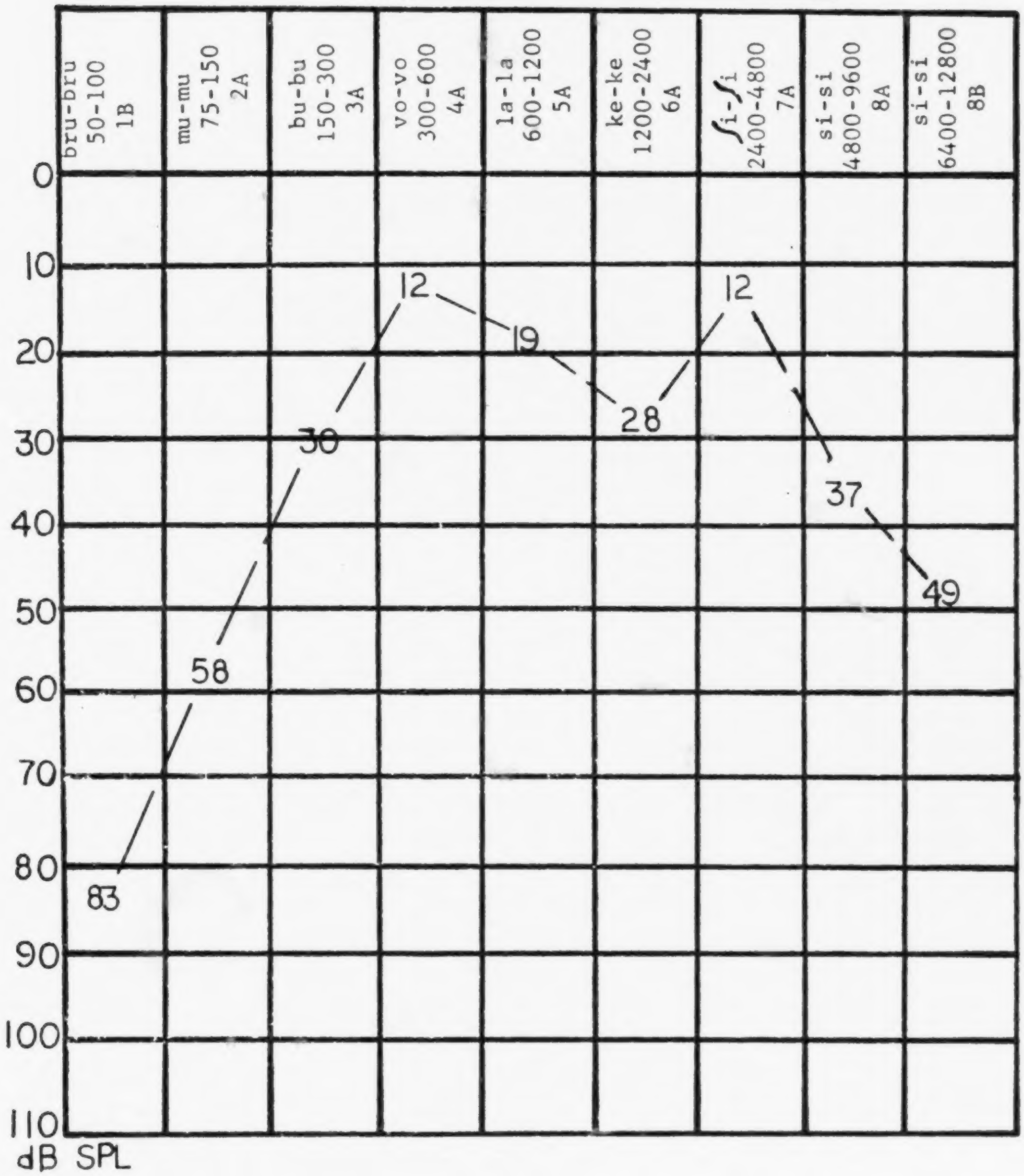


Figure 58.

Using the same design and rationale, the word lists seen in Figures 59 and 60 were constructed by the staff of our preschool program. These word lists take into account not only the frequency of occurrence in the English language, but also the actual frequency (Hz) of the various words. These lists need to be evaluated to see if they are equivalent in difficulty and in test — re-test reliability.

Figure 59 displays the preschool list and Figure 60 the adult list. Each list of 10 words contains 2 low, 2 low-middle, 2 middle, 2 middle-high, and 2 high-pitched words. Articulation functions can then be obtained with 5 such lists, and with pitch of the phoneme between lists being equated, the effect of various intensities can be measured. In addition, since these lists are short, obtaining an articulation function does not become an unwieldy task for the subject. These lists are now in the process of being taped.

Hearing Aids

There are 28 children enrolled in the preschool program. Fifteen of these children are wearing the Mini Suvag hearing aid, 8 children are wearing the Zenith Vocalizer II hearing aid and 5 children have not yet been fitted with hearing aids.

The children are fitted with either the Mini or the Zenith hearing aid on the basis of their assignment to either the Warren or the Suvag auditory training unit. The Suvag children wear Mini Suvag hearing aids and the Warren children wear Zenith aids. Children are fitted with hearing aids as soon as a reliable pure-tone audiogram has been obtained and it appears that they can benefit from amplification.

Time sheets are completed by the parents in order to monitor the amount of time the hearing aids are worn outside the therapy situation. Number of hours of hearing aid use has been referred to earlier in the report. For a different utilization of this data, see Chapter II. For most of the children, hearing aids are worn a high percentage of the day (an average of 57.6 hours/5-day week). A weekly check of the time sheets provides a quick and fairly accurate indication of difficulty with the hearing aid. For example, $S_{48(W)}$ has recently been fitted with a Zenith hearing aid. For the month of December, he wore the aid an average of 9 hours per day; during January this decreased to an average of 7 hours per day, and in the first two weeks of February it decreased again to an average of 2 hours per day. On the basis of this drop, it was determined that this subject was not wearing the hearing aid because of an improperly fitted earmold. The situation was remedied and the subject is again wearing the hearing aid on a more regular basis.

The hearing aids themselves are checked on a weekly basis. As would be expected, the most frequently occurring breakdown in performance is due to broken cords and/or receivers.

Individual earmold impressions for each child are made at the Center and the earmolds are checked periodically regarding proper fit. Most of the children in the program have been fitted with a "satin soft" type of earmold. The children seem to accept this type of impression quite readily and the mold seems to fit properly for a greater length of time.

At present, no formal testing is accomplished in the aided condition, although on occasion the children's perception with their hearing aids is

Figure 59. Preschool Word List

Each list contains 10 words: 2 low-frequency (L); 2 middle low-frequency (M-L); 2 middle-frequency (M); 2 middle high-frequency (M-H); and 2 high-frequency (H). Lists will be randomized for presentation.

I.

(1)	boo	L
(2)	under	M-L
(3)	tie	M-H
(4)	sister	H
(5)	mama	L
(6)	wool	M-L
(7)	lie	M
(8)	lady	M-H
(9)	tea	H
(10)	hello	M

II.

(1)	home	M-L
(2)	bow	L
(3)	letter	M
(4)	today	M-H
(5)	she	H
(6)	light	M-H
(7)	like	M
(8)	apple	L
(9)	see-saw	H
(10)	barber	M-L

III.

(1)	owl	M-L
(2)	play	M
(3)	untie	M-H
(4)	ahead	M
(5)	bubble	L
(6)	butter	M-L
(7)	tree	H
(8)	moo	L
(9)	easy	H
(10)	hat	M-H

IV.

(1)	lip	M
(2)	baby	L
(3)	hall	M-L
(4)	wheel	M-H
(5)	cheap	H
(6)	up	L
(7)	middle	M-L
(8)	dinner	M
(9)	today	M-H
(10)	easy	H

V.

(1)	ball	L
(2)	hello	M
(3)	drum	M-L
(4)	weigh	M-H
(5)	show	H
(6)	middle	M-L
(7)	lime	M
(8)	today	M-H
(9)	puppy	L
(10)	see	H

Figure 60. Adult Word List

Each list contains 10 words: 2 low-frequency (L); 2 middle low-frequency (M-L); 2 middle-frequency (M); 2 middle high-frequency (M-H); and 2 high-frequency (H). Lists will be randomized for presentation.

I.

(1)	rope	L
(2)	number	L
(3)	lawn	M-L
(4)	wood	M-L
(5)	dinner	M
(6)	tell	M
(7)	knee	M-H
(8)	kite	M-H
(9)	seashell	H
(10)	sick	H

II.

(1)	bird	L
(2)	apple	L
(3)	blood	M-L
(4)	under	M-L
(5)	ladder	M
(6)	good	M
(7)	knee	M-H
(8)	wheel	M-H
(9)	sister	H
(10)	cheat	H

III.

(1)	warm	L
(2)	pillow	L
(3)	home	M-L
(4)	banana	M-L
(5)	dinner	M
(6)	give	M
(7)	wheat	M-H
(8)	hit	M-H
(9)	catch	H
(10)	seashell	H

IV.

(1)	warm	L
(2)	baby	L
(3)	wool	M-L
(4)	pony	M-L
(5)	light	M
(6)	ahead	M
(7)	have	M-H
(8)	lady	M-H
(9)	tea	H
(10)	scissors	H

V.

(1)	blue	L
(2)	open	L
(3)	not	M-L
(4)	round	M-L
(5)	peel	M-L
(6)	ladder	M
(7)	hit	M-H
(8)	keep	M-H
(9)	show	H
(10)	easy	H

VI.

(1)	buy	L
(2)	paper	L
(3)	drum	M-L
(4)	butter	M-L
(5)	might	M
(6)	tell	M
(7)	here	M-H
(8)	untie	M-H
(9)	sick	H
(10)	cheat	H

VII.

(1)	blow	L
(2)	purple	L
(3)	head	M-L
(4)	middle	M-L
(5)	cook	M
(6)	hello	M
(7)	test	M-H
(8)	tie	M-H
(9)	itch	H
(10)	sister	H

VIII.

(1)	wipe	L
(2)	animal	L
(3)	man	M-L
(4)	pony	M-L
(5)	lime	M
(6)	dinner	M
(7)	wheat	M-H
(8)	today	M-H
(9)	sick	H
(10)	seashell	H

checked. When previously mentioned frequency-balanced word lists are taped, these lists will also be used to test speech discrimination with the hearing aid.

CHAPTER VII

REHABILITATION PROGRAM

Elsie H. French, M.A. and Dianne R. Vertes, M.A.

Subjects

In February, 1971, a Rehabilitation Section was added to the total program. Since that time, twenty-three cases either have been or are currently being seen for therapy. Table 25 displays the ages of these subjects at the time they entered the rehabilitation program, their initial date of therapy in this section, the degree and onset of the hearing loss, and the type of therapy they received.

For this chapter each rehabilitation case is identified by a number (1-23) preceded by the letter R. The first name and the initial of the last name are included for additional identification, e.g., R-1, Karen C. For the discussion in this chapter, the subjects will be referred to by the letter R and the identification number only; no names will be used; e.g., R_1, R_{13}, etc.

R_1 through R_{15}, or fifteen of the total twenty-three rehabilitation cases were 18 years of age or younger and were classified as children. These children comprise 65% of the total rehabilitation caseload. Nine of these subjects were children who were previously in our preschool program. These include the following: R_1, R_2, R_4, R_5, R_6, R_8, R_9, R_{10}, and R_{11}. Measurements on some of these cases (R_1, R_2, R_4, R_5, R_6, R_{10}) were discussed in an earlier chapter. The remainder of this group, R_3, R_7, R_{12}, R_{13}, R_{14}, and R_{15} were children who did not participate in the Verbo-tonal preschool program. The age range of these fifteen children was from 6 years, 5 months to 18 years with a mean age of 9 years, 11 months.

Of these 15 children, five had moderate hearing losses (40-59 dB HL), five had severe losses (60-79 dB HL), and five had profound losses (80 dB HL or greater). This information is displayed in Table 25. All of these losses were congenital except one. R_{14} had a hearing loss acquired at age four. On the other hand, R_{12} had a congenital hearing loss that was progressive.

All of these subjects were scheduled three times per week for 30 minute therapy sessions.

One case in this group was discontinued. R_{14} was a college student who moved out of town to work.

R_{16} through R_{23} were over 18 years of age and were classified as adults. The age range for the adults was from 22 years to 76 years, with a mean age of 50 years, 10 months. This group consisted of 8 subjects and comprised 35% of the total rehabilitation section.

Of this group, there were two with mild losses (25-39 dB HL), two with moderate losses (40-59 dB HL), two with severe losses (60-79 dB HL), and two with profound losses (80 dB HL or greater). Table 25 displays this information.

Only one of these cases had a congenital loss, three had acquired progressive losses, and four were presbycusic.

TABLE 25

DESCRIPTIVE INFORMATION FOR REHABILITATION SUBJECTS

Subject Identification	Age Yrs.-Mos.	Therapy Began	Degree of Loss	Onset ***	Type of Therapy ****
R_1, Karen C.**	6-5	Sept.'71	sev.	C	1
R_2, Ann O.**	6-8	April '71	mod.	C	2
R_3, Cliff R.	6-9	Feb. '71	sev.	C	1
R_4, Kenneth B.**	6-10	Sept.'71	sev.	C	1
R_5, Michael P.**	7-0	Sept.'71	prof.	C	1
R_6, Dewayne D.**	7-1	Sept.'71	prof.	C	1
R_7, Harry B.	7-1	Feb. '72	mod.	C	2
R_8, Steve R.*	7-10	April '71	prof.	C	1
R_9, John M.*	7-10	April '71	sev.	C	1
R_{10}, Tracy Z**	8-8	April '71	prof.	C	1
R_{11}, Brian M.*	8-11	April '71	prof.	C	1
R_{12}, Teresa C.	11-3	Feb. '71	mod.	C.P.	2
R_{13}, Jane E.	11-7	April '71	sev.	C	2
R_{14}, Boyd B.	17	Feb. '71	mod.	A	2
R_{15}, Cindy M.	18	June '71	mod	C	2
R_{16}, Glenda T.	22	Sept.'71	prof.	C	2
R_{17}, Elaine M.	27	June '71	prof.	A.P.	2
R_{18}, Betty M.	46	Feb. '72	mod.	A.P.	2
R_{19}, Grant C.	47	Jan. '72	sev.	A.P.	2
R_{20}, William M.	56	Mar. '71	mod.	P	2
R_{21}, Clara R.	62	Feb. '71	mild	P.	2
R_{22}, Genevieve P.	68	July '71	mild	P	2
R_{23}, Ralph C.	76	Feb. '72	sev.	P	2

KEY:

* = Previously in Verbo-tonal Preschool, but no measurements reported in earlier data
** = Measurements reported in earlier data
*** = C- congenital
C.P.- congential progressive
A- acquired
A.P.- acquired progressive
P.- presbycusis
**** = (1) production, perception, and association utilizing phonetic progression and optimal field of hearing
(2) auditory perception utilizing optimal field of hearing

Therapy for R_{16} was temporarily discontinued because of a transportation problem. Attempts will be made to re-schedule her at a later time.

All of the cases in this group were scheduled twice per week for 30-minute sessions except the two with profound losses. R_{16} and R_{17} were scheduled three times per week for 30-minute sessions.

The therapy procedure utilizing optimal fields of hearing to enhance auditory perception was utilized for all of these cases. This technique will be referred to in the following section.

Type of Therapy

The type of therapy for each subject was decided after a diagnostic therapeutic evaluation.

With the exception of R_2, all of the children who had previously been in the preschool program continued working on the phonetic progression as described earlier in this report. In addition, the optimal fields of hearing were utilized to improve production, perception, and association. R_2 had a moderate hearing loss and was able to enter a normal-hearing kindergarten. Her auditory perception for most phonemes and her communication skills were sufficiently developed to allow her to advance to the purely auditory perceptual aspect of training. Of the children who did not participate in the Verbo-tonal program as preschoolers, therapy for R_3 consisted of training in production, perception, and association, whereas therapy for R_7, R_{12}, R_{13}, R_{14} and R_{15} consisted only of auditory perception.

All of the adults (R_{16} - R_{23}) utilized the auditory perception level of training, which is based upon optimal fields of hearing. Only R_{16} in this group had a profound hearing loss and was congenitally deaf. The remainder of this group had normal speech patterns and needed specific work on auditory perception. R_{16} was scheduled for therapy for the phonetic progression and optimal field of hearing because of the severity of her hearing loss. However, she has temporarily dropped out of the program because of schedule problems.

Therapy Technique

The reader is referred to Chapter II for a description of therapy procedures utilizing the phonetical progression and optimal field of hearing for the development of speech production, perception, and association. This procedure is also outlined in Chapter X in the paper entitled The Verbo-tonal System. The same procedure was utilized for the children previously identified in the Rehabilitation section as receiving this type of therapy. Comparatively speaking, the rehabilitation cases had the disadvantage of receiving less therapy in terms of the total possible hours per week. On the other hand, they had the distinct advantage of having individualized therapy for the entire session, as opposed to group therapy with some individual attention 2 to 3 times per week.

The reader is referred to Chapter X in the paper entitled The Verbotonal System for a complete outline of the Rehabilitation Procedure. A typical session with a hard-of-hearing patient with an acquired hearing loss is described in Section 8 under Rehabilitation.

The following section of this chapter will contain a description of the various audiometric measures obtained with the rehabilitation cases. It will also describe in detail some noticeable improvements made by three of these cases. It should be noted that these improvements represent enhanced performance following months of therapy as opposed to similar improvements that might take years with preschool children.

Pure-Tone and Speech Testing

All rehabilitation cases are seen for pure-tone evaluation. It is important that these measures be taken even if previous audiological evaluation at another center has been relatively recent. In order to precisely quantify improvements with therapy, a complete pre-therapy audiological evaluation must be used as the basis for comparison. The rehabilitation cases are seen less often for repeat testing than the preschool children, since the hearing losses have usually stabilized. However, four cases of progressive hearing loss have been detected.

Persons who are able to respond are given various speech tests. Speech reception thresholds and speech discrimination scores are compared to previous test results in order to assess progress in the aural rehabilitation program. In an effort to standardize results from one test to the next, taped lists are used. In another attempt to utilize speech test results, errors are recorded and analyzed with respect to perception.

Improvement in speech discrimination ability has been noted in several persons enrolled in the program. One example is Boyd B. (R_{14}), age 17, who has been enrolled in the program since February 1, 1971 (See Table 25). The pure-tone audiogram may be seen in Figure 61 . Testing on September 17, 1970, indicated scores of 20 percent in the right ear at a 95 dB hearing level (HL) and 58 percent in the left ear at 70 dB HL. Testing on May 13, 1971 indicated scores of 24 percent at 95 dB HL, and 76 percent at 90 dB HL for the right and left ears, respectively. It can be seen that at the same test levels, discrimination ability in the left ear improved 18 percent.

Another example is Elaine M. (R_{17}), age 27, whose audiograms (pure-tone and Verbo-tonal) may be seen in Figures 62 and 63 . Elaine was enrolled in the program on June 28, 1971. Initial testing on November 3, 1971, indicated speech discrimination scores of 6 percent in the right ear at 95 dB HL and 2 percent in the left ear at 95 dB HL. It was noted at that time that the subject was able to perceive vowel sounds quite well, but speech scores were profoundly depressed since perception of consonant sounds was poor -- if not absent altogether. Retest on February 14, 1972, indicated scores of 18 percent at 85 dB HL and 24 percent at 85 dB HL for the right and left ears, respectively. Test results showed improvement in two directions: one direction is that the subject was able to discriminate at a 10 dB lower sensation level (85 dB vs 95 dB), and secondly, the improvement in discrimination. This improvement was 12 percent in the right ear and 22 percent in the left ear.

A third and final example of improvement is that of Genevieve P. (R_{22}), age 68. Two different audiograms may be seen in Figures 64 and 65 . After approximately 5 months of therapy, improvement was seen in two types of speech tasks. Speech reception thresholds at the May 31, 1971, evaluation were 45 dB - right and 45 dB - left. At the October 20, 1971, evaluation these scores improved to levels of 30 dB and 40 dB for the right and left ears, respectively. In addition, there was improvement in speech

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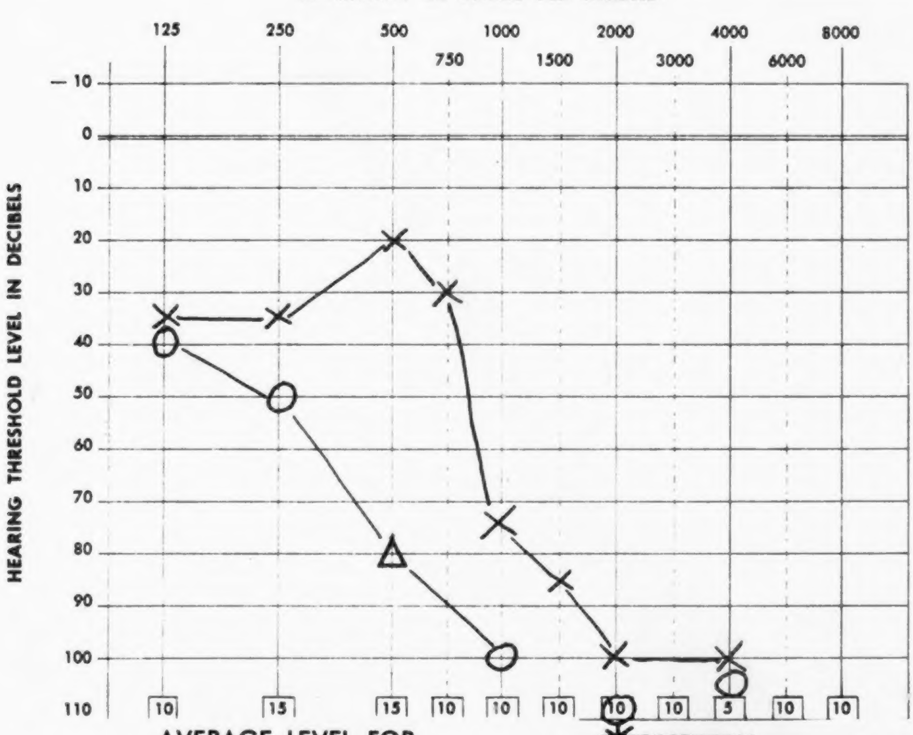
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name Boyd B. Date of Evaluation 5-13-71



AVERAGE LEVEL FOR TEST TONES

SPEECH RECEPTION AWARENESS THRESHOLDS

(500, 1000 & 2000 cps)

3F AIR: Rt 96+ dB Lt 65 dB

2F AIR Rt 90 dB Lt 47 dB

125&250 RT. 45 dB LT 35dB

LIVE-VOICE SPONDEES OTHER

AWARENESS

Rt 65 dB Lt 55 dB

FIELD: ______ dB

(ALL LEVELS RE NORMAL SRT)

SPEECH DISCRIMINATION

PB-50 W22 PKB OTHER LV REC

Rt 24 % at MAXIMUM dB

Lt 76 % at 35 dB

Field ______ % at ______ dB

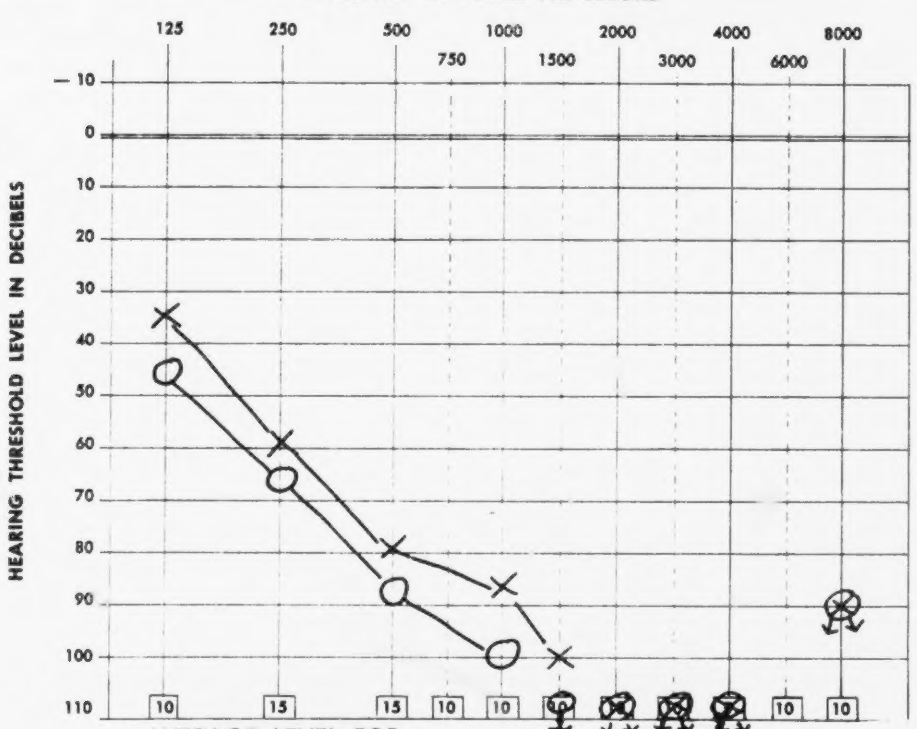
(ALL LEVELS RE CLIENT'S SRT)

Figure 61.

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name Elaine M. Date of Evaluation 11-3-71



AVERAGE LEVEL FOR TEST TONES

SPEECH ~~RECEPTION~~ [✓ AWARENESS] THRESHOLDS

(500, 1000 & 2000 cps)

3F AIR: Rt 98+ dB Lt 91+ dB

2F AIR Rt 92 dB Lt 82 dB

125&250 Rt. 55 dB Lt. 47 dB

LIVE-VOICE SPONDEES OTHER

Rt 85 dB Lt 75 dB

FIELD: dB

(ALL LEVELS RE NORMAL SRT)

SPEECH DISCRIMINATION

PB-50 W22 PKB OTHER LV REC

Rt 2 % at 95 dB HTL

Lt 6 % at 95 dB HTL

Field % at dB

(ALL LEVELS RE CLIENT'S SRT)

Figure 62.

VERBO-TONAL AUDIOGRAM

Name Elaine M. Test Optimal Detection (Filtered)

Date 2/9/72

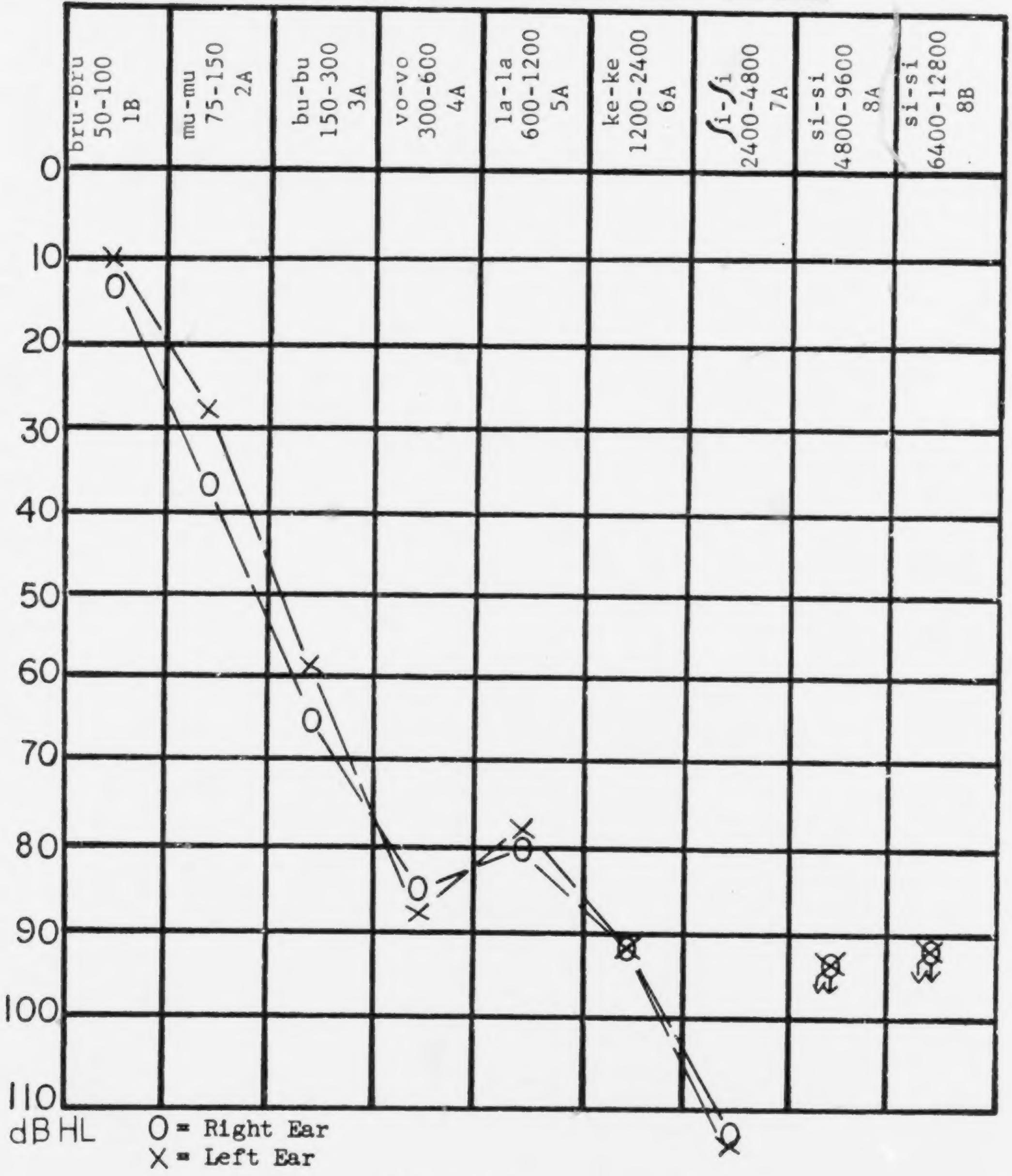
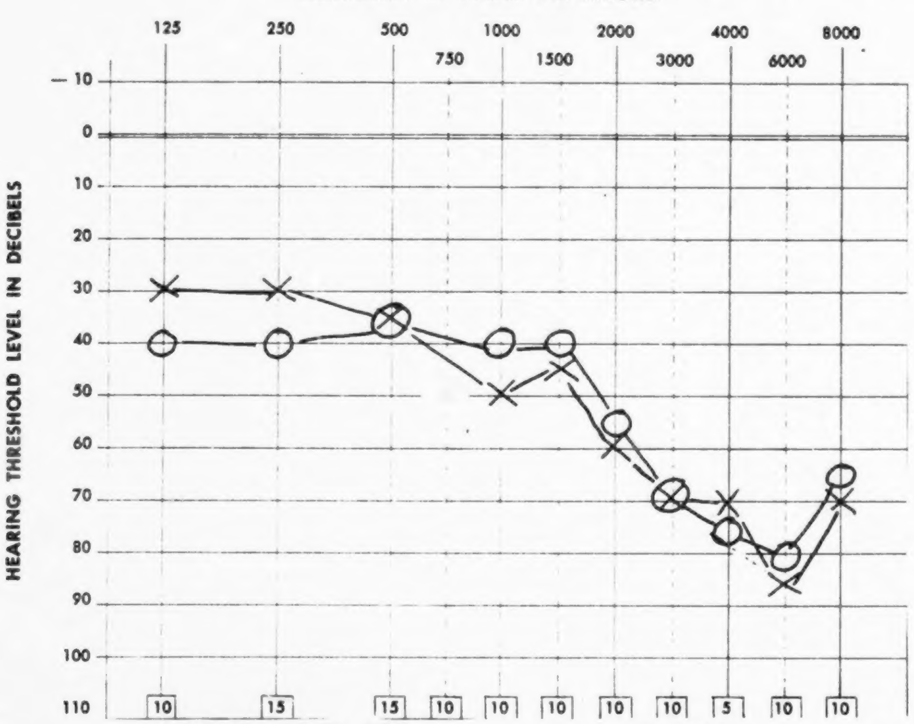


Figure 63.

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name Genevieve P. Date of Evaluation 5-31-71



AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt 43 dB Lt 48 dB

2F AIR Rt 37 dB Lt 42 dB

125&250 RT 40 dB LT 30 dB

SPEECH RECEPTION ~~AWARENESS~~ THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt 45 dB Lt 45 dB

FIELD: _____ dB

(ALL LEVELS RE NORMAL SRT)

SPEECH DISCRIMINATION

PB-50 [✓ W22] PKB OTHER [✓ LV] REC

Rt 84 % at 85 dB HTL

Lt 62 % at 80 dB HTL

Field _____ % at _____ dB

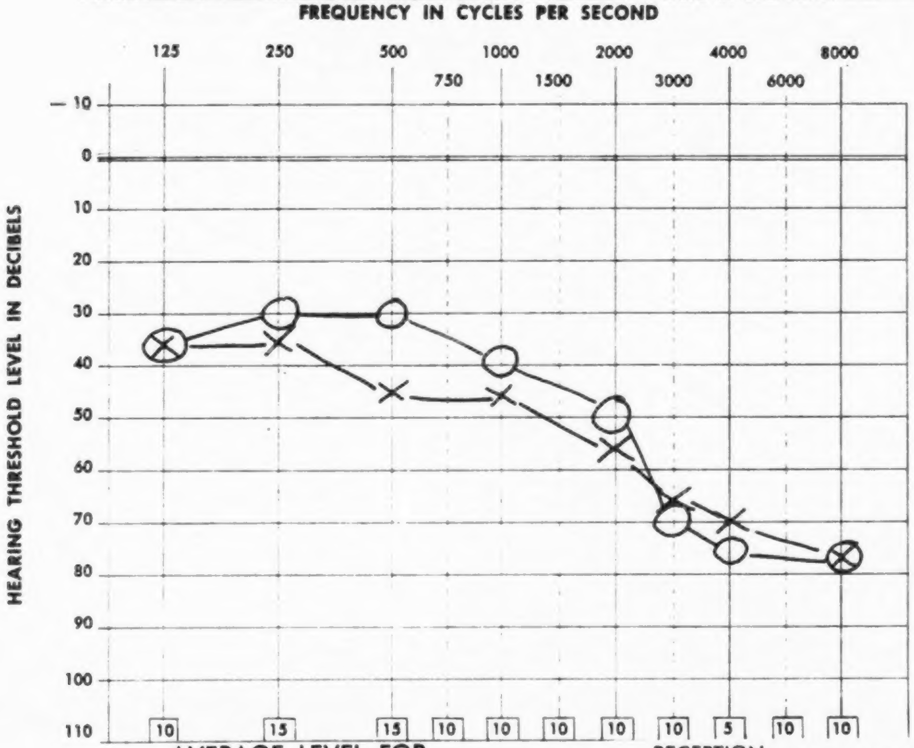
(ALL LEVELS RE CLIENT'S SRT)

Figure 64.

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name Genevieve P. Date of Evaluation 10-20-71



AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt 40 dB Lt 48 dB

2F AIR Rt 35 dB Lt 45 dB

125 & 250 RT 32 dB LT 35 dB

SPEECH RECEPTION ~~AWARENESS~~ THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt 30 dB Lt 40 dB

FIELD: ______ dB

(ALL LEVELS RE NORMAL SRT)

SPEECH DISCRIMINATION

PB-50 W22 PKB OTHER LV REC

Rt 76%/82% at 70/50 dB HTL

Lt 64%/86% at 70/80 dB HTL

Field ______ % at ______ dB

(ALL LEVELS RE CLIENT'S SRT)

Figure 65.

discrimination ability in both ears. In the right ear, the subject maintained almost the same score (82 percent at 50 dB vs 84 percent at 85 dB) at a 35 dB less intense presentation level. These presentation levels represent the difference between normal conversational level (50 dB HL) and a very loud speech level (85 dB HL). In the left ear, the same presentation level (80 dB HL), the subject improved 24 percent from the previous test. This improvement was from 62 to 86 percent.

Verbo-Tonal Testing

For a complete description of Verbo-tonal testing, the reader should refer to the preceding Chapter. As noted so often in the literature, the validity and reliability of most audiological tests increases with increased age of the patient. Generally, older children and adults are better able to respond to complex audiological tasks of relatively long duration than are younger children. As a result, a greater number of the Verbo-tonal tests have been administered to this rehabilitation group. The addition of the rehabilitation section, then, has had the additional advantage of bringing about a more complete understanding of Verbo-tonal audiometry.

Optimal detection (filtered), low transfer, high transfer and discontinuous transfer testing have been accomplished. The test results are used to identify the optimal field of hearing for rehabilitation with Suvag II. An example of this type of testing for an eleven year old, Teresa C. (R_{12}), may be seen in Figures 66 and 67. Figure 66 is the test of filtered logotomes and Figure 67 the test of transfer. Teresa's pure-tone audiogram has been included for comparison and is shown in Figure 68 . As can be seen by both the pure-tone and Verbo-tonal (filtered) audiograms, this subject has better hearing in the low frequencies than in the high frequencies. What the Verbo-tonal audiogram (as opposed to the pure-tone audiogram) indicates, however, is that this subject is able to utilize high frequency information. The optimal detection audiogram (Figure 66) indicates better thresholds for the two high-frequency bands with the logotome /si-si/, whereas the pure-tone audiogram (Figure 68) does not indicate this. One indication of how effectively the subject is utilizing the low frequencies may be seen in the transfer test in Figure 67 . The low transfer curve in this graph indicates that this subject is detecting the presence of a high-frequency logotome /si-si/ when it is passed through low-frequency octave bands ranging from the 75-100 Hz band to the 600-1200 Hz band. These test results give some indication of the subject's "optimal" frequency range for perception.

Further diagnostic information may be gained from the discontinuous transfer threshold in Figure 67 . This threshold is the level at which a subject can detect the presence of a high-frequency logotome /si-si/ when presented through two discontinuous bands of 150-300 Hz, and 6400-12,800 Hz. As can be seen by comparing Figures 66 and 67 , the low frequencies do seem to enhance the perception of the high frequencies. Thresholds improved from 71 dB (octave band 8B) to 32 dB (3A and 8B) in the left ear, and from 63 dB (8B) to 34 dB (3A and 8B) in the right ear. If the discontinuous transfer threshold is also compared to the low-transfer threshold at 3A (150-300 Hz), a final observation can be made. When /si-si/ is passed through the 150-300 Hz band, it is detected at 13 dB and 17 dB for the right and left ears, respectively. When /si-si/ is passed through the discontinuous bands 150-300 Hz and 6400-12,800 Hz, thresholds are 34 dB for the right ear and 32 dB for the left ear. This result seems to indicate that the high frequencies are not being utilized as profitably as they could be, and thus indicates the direction of further therapy.

VERBO-TONAL AUDIOGRAM

Name Teresa C. Test Optimal Detection (Filtered)

Date 11/29/71

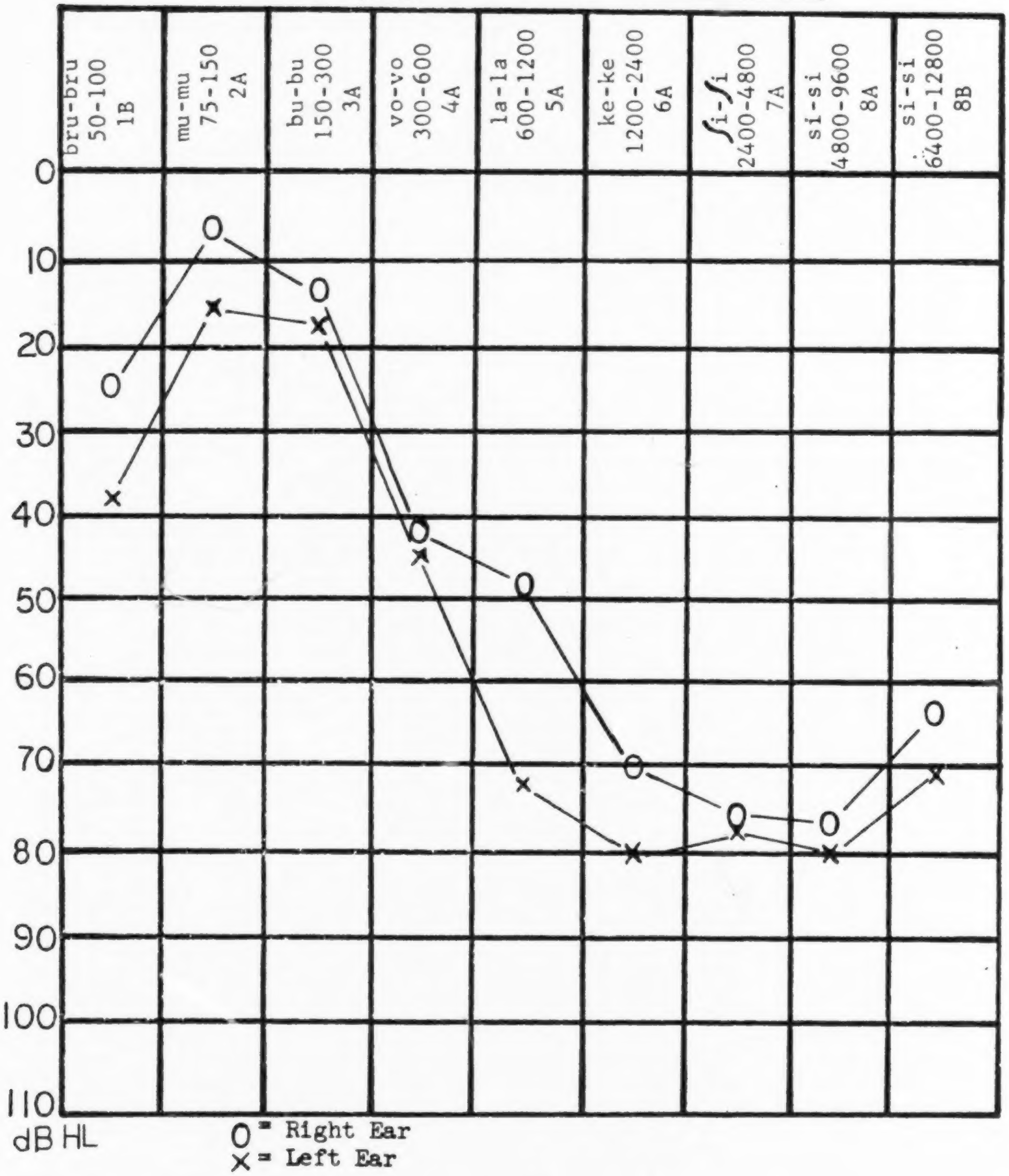
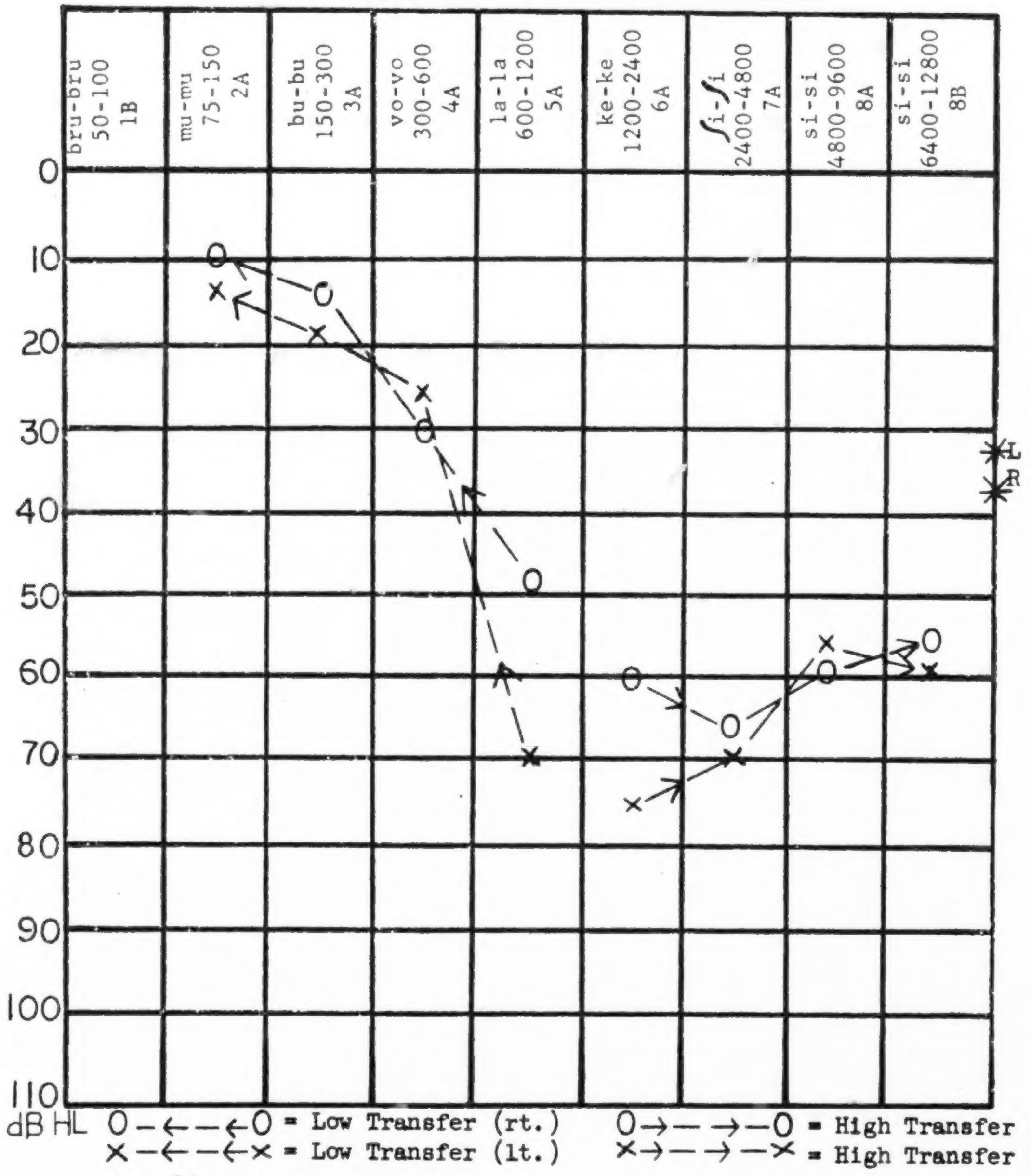


Figure 66.

VERBO-TONAL AUDIOGRAM

Name Teresa C. Test Low Transfer, High Transfer, Discontinuous Transfer

Date 11/29/71



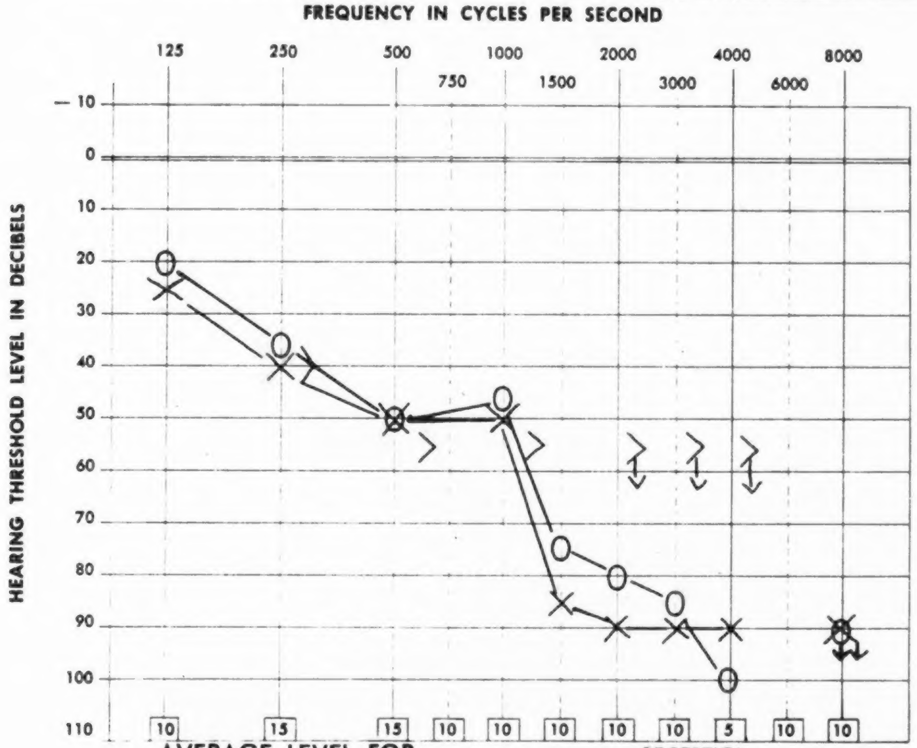
O—←—←O = Low Transfer (rt.)
X—←—←X = Low Transfer (lt.)
✳ = Discontinuous Transfer
O→—→—O = High Transfer (rt.)
X→—→—X = High Transfer (lt.)

Figure 67.

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name TERESA C. Date of Evaluation 10-13-71



AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt 58 dB Lt 63 dB

2F AIR Rt 47 dB Lt 50 dB

125+250 RT 27 dB LT 32 dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt 55 dB Lt 55 dB

FIELD: ____ dB

(ALL LEVELS RE NORMAL SRT)

SPEECH DISCRIMINATION

PB-50 W22 PKB OTHER LV REC

Rt 54 % at 95 dB HTL

Lt 66 % at 95 dB HTL

Field ____ % at ____ dB

(ALL LEVELS RE CLIENT'S SRT)

Figure 68.

Hearing Aids

Hearing aid usage in the rehabilitation section varies; body-type and ear-level hearing aids are worn. Some of the subjects are not wearing hearing aids at this time. The Mini Suvag hearing aid is worn by the following: R1, R4, R5, R6, R10 and R17. Commercially-available body hearing aids are worn by R2, R3, R7, R8, R9, R11 and R16. Commercially-available ear level hearing aids are worn by R12, R13, R19 and R23. The other rehabilitation cases (R14, R15, R18, R20, R21 and R22) and not currently using any wearable type of amplification.

Therapy, especially with the cases who are not using hearing aids, is designed to improve perception to the point where amplification will not be necessary, or to the point where the person can profit from presently available amplification. It is true, in fact that many of the above mentioned cases do possess their own hearing aids, but do not wear them because of the minimal benefit that the aids provide.

One interesting example of hearing aid usage is that of Elaine M. (R17) whose pure-tone audiogram may be seen in Figure 62. Elaine, who is 27 years old, has worn a conventional ear level hearing aid for approximately 17 years. After 6 months in therapy, however, she voluntarily chose to wear the Mini Suvag hearing aid, because it greatly improved her aided perception. This case is unique for two reasons. First, it is rare for a person who has been wearing one type of amplification for so many years to change to a completely different type. It seems that after a person becomes accustomed to a certain type of hearing aid (and its particular type of distortion), they learn to discriminate with and perceive this input signal. Usually, there is a certain reluctance to change to another hearing aid (a different type of distortion) since this would necessitate relearning to perceive and discriminate with a different input signal. However, as previously mentioned, Elaine felt that the Mini Suvag hearing aid actually improved her perception. The second reason that this change was felt to be unique is because of the age and sex of this subject. From past experiences and from the reports of this subject, it is very difficult for a 27 year-old female to change from the less obvious ear level hearing aid to a more obvious body aid. Since the Mini has improved her ability to perceive speech, Elaine continues to wear this body aid because it improves her ability to communicate.

CHAPTER VIII

EVALUATION OF AUDITORY TRAINING UNITS AND HEARING AIDS

James E. Keller, B.S.,
Philip Williams and Carl Sellers

This research project requires electronic instrumentation for both clinical and research activities. Beyond the daily needs of maintenance of the units, there is a need to identify the specific characteristics of each unit, and to evaluate and compare the units. This identification and evaluation is extremely important in order to evaluate the effectiveness of low-frequency amplification from a technical point of view.

Another aspect of the instrumentation was the need to design, construct, and evaluate new systems for obtaining and evaluating behavioral data. Most of the systems are not commercially available because they are unique to this project; for example, the automatic system for measuring the rate and duration of the vocalizations.

Chapters VIII and IX will discuss the electronic instrumentation for this project. Chapter VIII will evaluate auditory training units and hearing aids. Schematic designs will be included, so that the reader will have a better understanding of the units under test. The inclusion of schematics does not imply any license under the patent rights of the manufacturer. Permission should be received from the manufacturers before any of this information is utilized. Manufacturers of the units in Chapter VIII are as follows: (1) Societi Sedi for Suvag I, Suvag II, and Mini Suvag; (2) Domenico Kozulic for Suvag Vibar (bone vibrator); (3) Jay L. Warren Inc. for the Warren Auditory Training Unit; and (4) Zenith Corporation for the Zenith Vocalizer II hearing aid.

The evaluation of these units was completed with the following test equipment:

(1) Tektronix oscilloscope, type 561B with type 3A3 vertical amplifier and type 3B3 time base.
(2) Brüel & Kjaer Beat Frequency Oscillator, type 1022
(3) " " Frequency Analyzer, type 2107
(4) " " Microphone Amplifier, type 2603
(5) " " Level Recorder, type 2203
(6) " " Hearing Aid Test Box, type 4212
(7) " " Microphone Calibrator, type 4142
(8) " " Artificial Ear, type 4153
(9) " " Cathode Follower, type 2615
(10) " " FET Preamplifier, type 2618
(11) " " Condenser Microphone, type 4132
(12) " " Condenser Microphone, type 4145
(13) " " Microphone Power Supply, type 2801
(14) Suttle Sound-treated Booth, model SE-224
(15) Utah Speaker, model C12PC3B

Some of the measurement techniques had to be adapted for specific purposes. To obtain an acoustical frequency response lower in frequency than the capabilities of the hearing aid test box, the procedure in Figure 69 was used. This procedure is not ideal, however, the response of the sound-treated booth (Suttle, model SE-224) in Figure 70 shows the uncontrollable resonance of the room. Acoustical responses in the sound-treated room should be compared to the room response in Figure 70. For

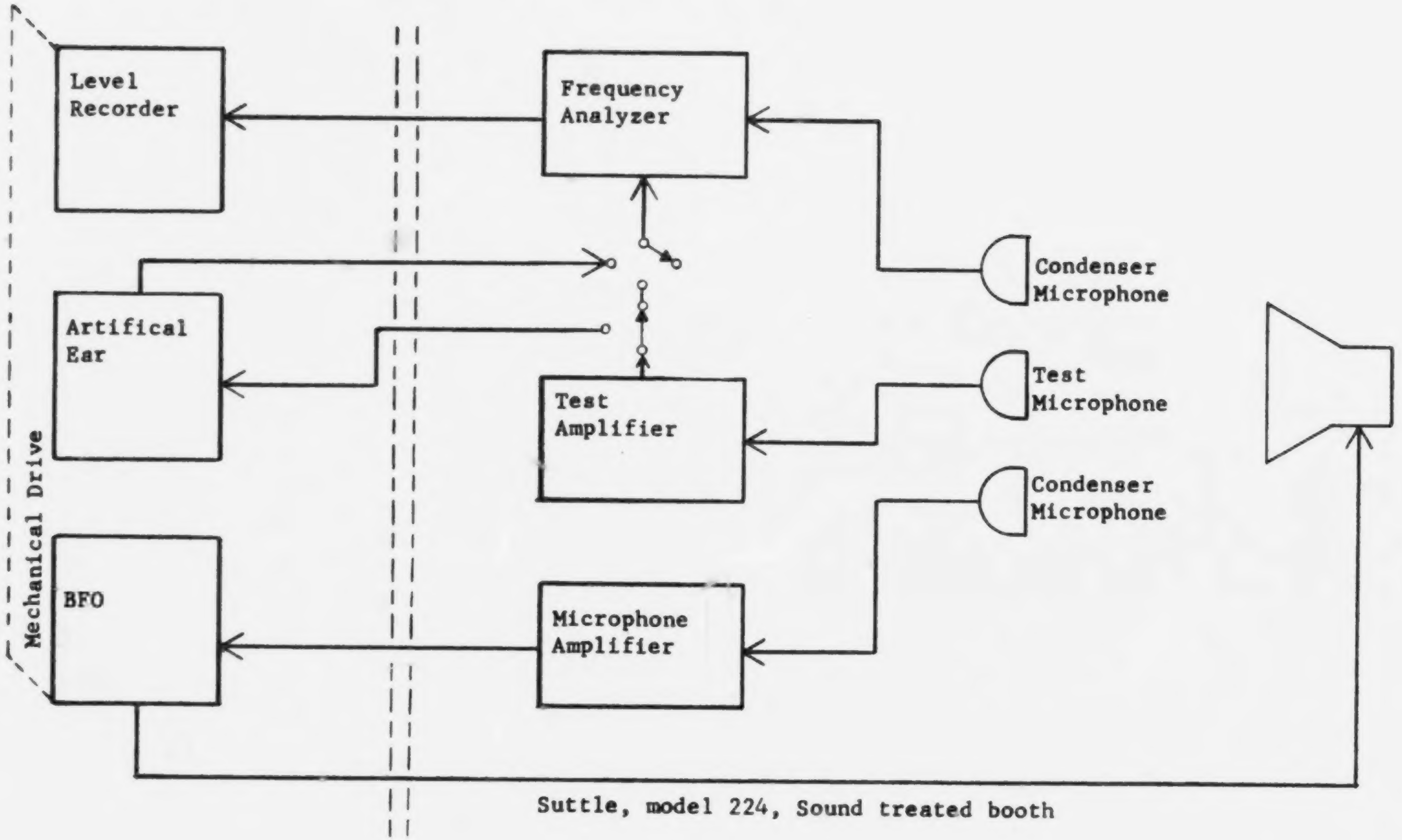

Level Recorder
Frequency Analyzer
Artifical Ear
Test Amplifier
BFO
Microphone Amplifier
Mechanical Drive
Condenser Microphone
Test Microphone
Condenser Microphone
Suttle, model 224, Sound treated booth

Figure 69. Block diagram of acoustical test apparatus.

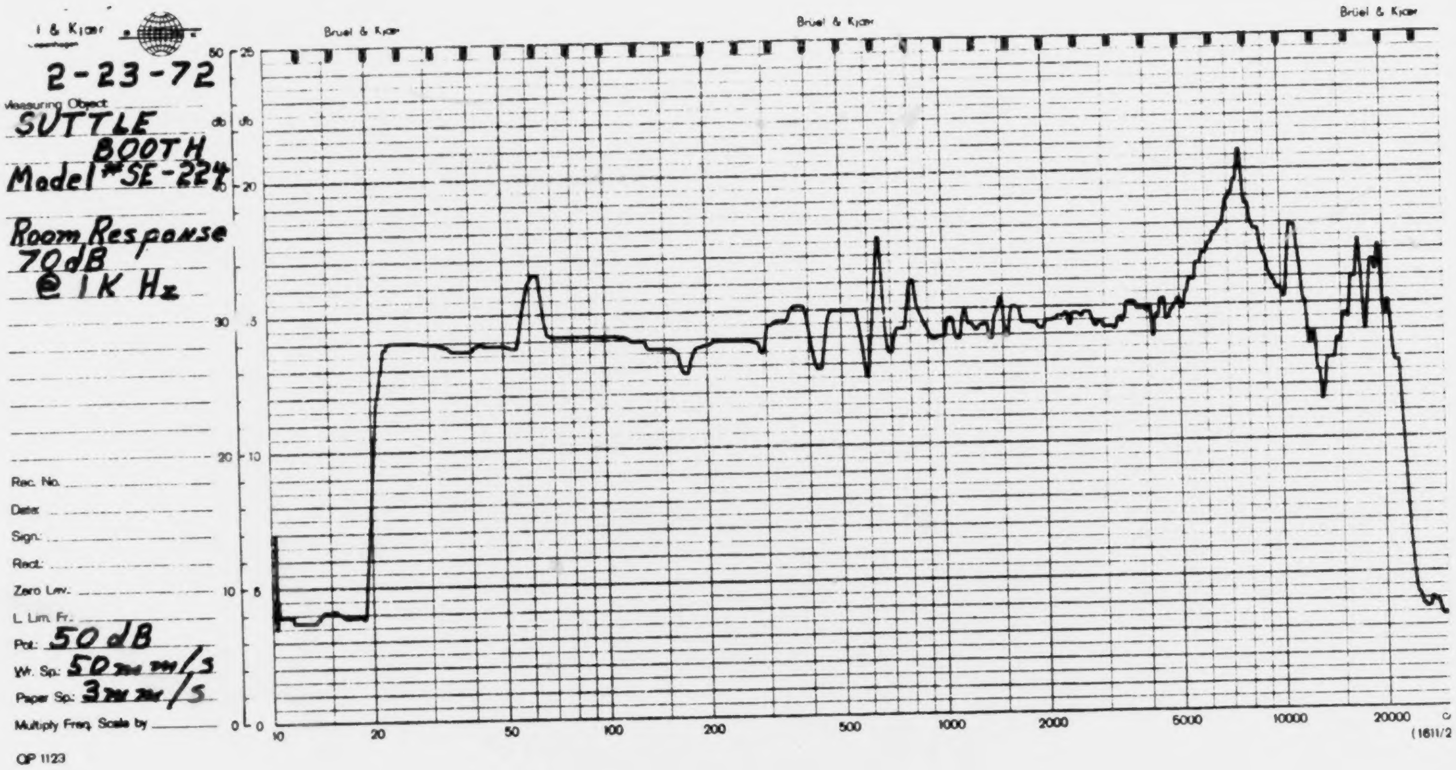


Figure 70. Acoustical frequency response of the Suttle Model SE-224 sound treated booth.

obtaining electrical frequency responses, each unit under test was driven by equivalent circuits of the appropriate input transducers, and they are identified for each frequency response.

The order of presentation will be as follows:

(1) Suvag I auditory training unit
(2) Warren Model T-2 auditory training unit
(3) Suvag II auditory training unit
(4) Mini Suvag hearing aid
(5) Zenith Vocalizer II hearing aid
(6) Rack output for the classrooms using Suvag I and Warren T-2 auditory training units

Suvag I Auditory Training Unit

The block diagram seen in Figure 71 shows the basic sections of the Suvag I auditory training unit. The low-pass filters provide a choice of four cut-off frequencies (.6, 1, 2, or 3 KHz). For each of these cut-off frequencies, there are four discrete roll-offs to the left (0, 6, 12, and 18 dB/octave) and two to the right (20 and 65 dB/octave). A schematic diagram for this circuit may be seen in Figure 72 and the operation of this circuit will be covered in the section on the Suvag II. These filters are not used in the experimental classrooms and remain in the "off" position. The remaining circuitry consists of a pre-amplifier and power amplifier. The specifications and frequency responses for the 079 unit were evaluated in our electronic and acoustical laboratory.

The following is a list of specifications and frequency responses:

(1)	Input sensitivity	8.1 mVRMS for rated output
(2)	Output voltage	12.5 VRMS into a 10 ohm load
(3)	Output power	15.6 watts RMS into a 10 ohm load
(4)	Output impedance	10, 20, 30, 60, and 100 ohms
(5)	Signal to noise ratio	50 dB
(6)	Frequency responses	
	electrical input vs electrical output	(see Figure 2)
	electrical input vs acoustical output	" " 6
	acoustical input vs electrical output	" " 73
	acoustical input vs acoustical output	" " 74

Figure 75 shows the schematic diagram of the preamplifier in the Suvag I. It is designed to effectively amplify the wide frequency response of a crystal microphone. Ideally, this stage of the amplifier should have an input impedance of infinity. Since this is not possible, it was found that four crystal microphones connected in parallel would reduce the impedance of the microphone to a more reasonable value. The input impedance of the amplifier was then designed to achieve the best possible frequency characteristics. The 10 Meg ohm resistor, connected between the control grid and cathode of the first stage, provides a resistive component of approximately 10 Meg ohms. To achieve a more suitable input impedance a .033 micro-farad capacitor is placed across the input. The capacitive component decreases the input impedance as the frequency increases, which opposes the increased impedance of the microphone at low frequencies. The end result is a relatively-flat frequency response of the combined microphone and preamplifier.

The preamplifier also provides voltage amplification. An attenuator, located between the second and third stages, regulates the gain of this section. It should be noted that the dynamic range of the preamplifier is

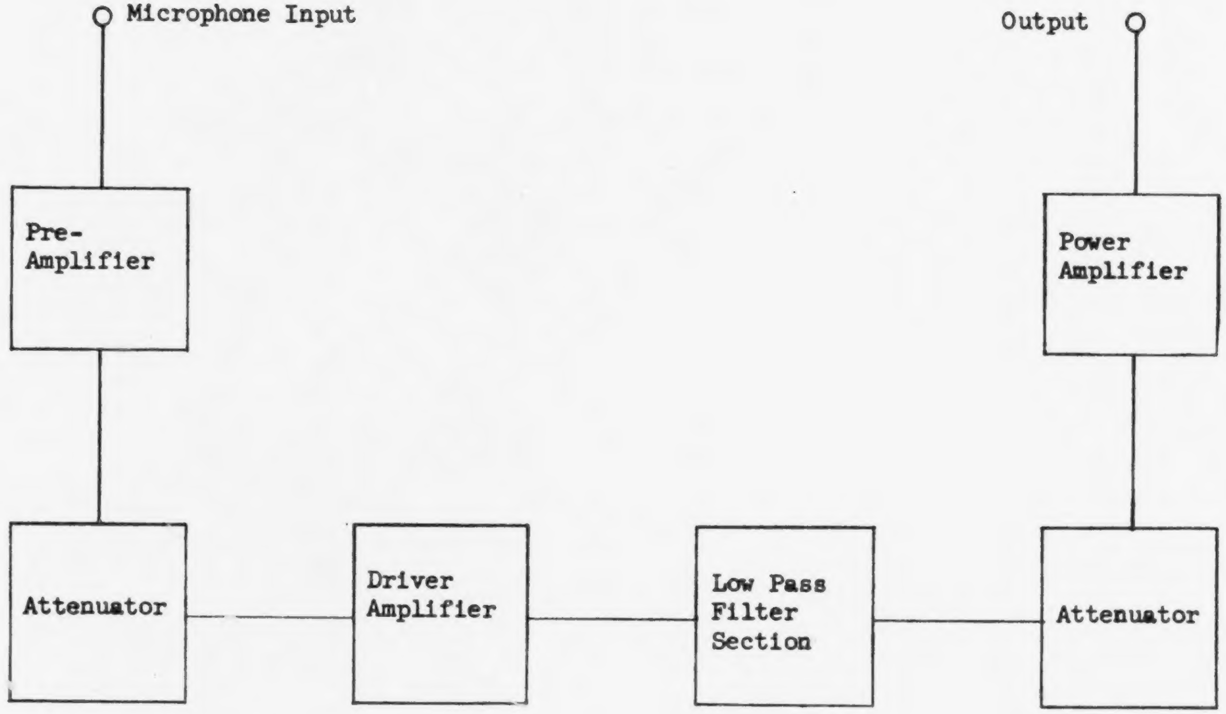
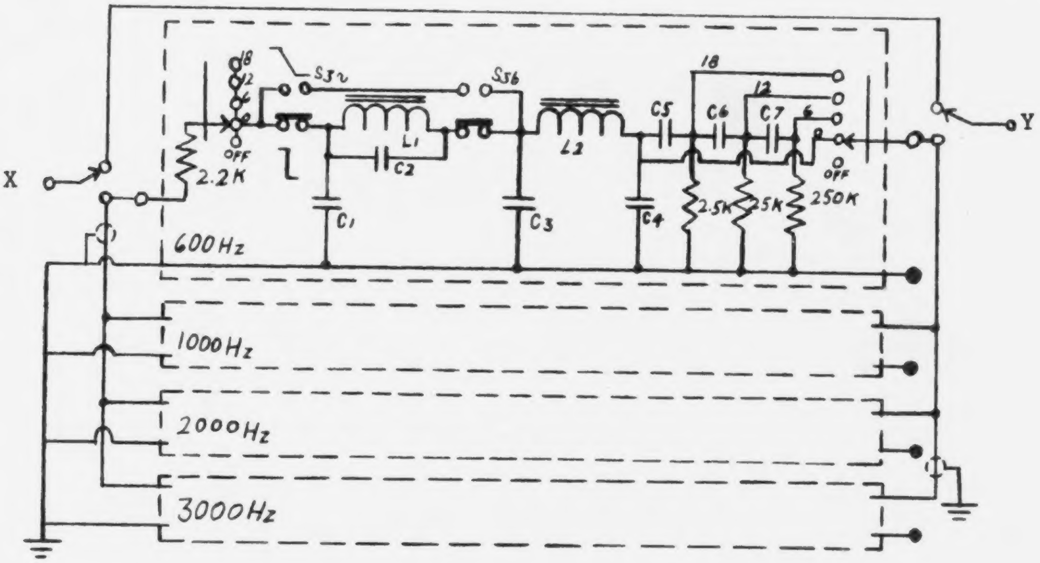

Microphone Input
Output
Pre-Amplifier
Power Amplifier
Attenuator
Driver Amplifier
Low Pass Filter Section
Attenuator

Figure 71. Block diagram of the Suvag I Auditory training unit.


X
Y
18
12
6
OFF
S3a
S3b
2.2K
L
L1
C2
C1
C3
L2
C5
C6
C7
C4
18
12
6
OFF
2.5K
25K
250K
600Hz
1000Hz
2000Hz
3000Hz

Filter	C1	C2	C3	C4	C5	C6	C7	L1	L2
600 Hz	73.5	10.7	157	83.5	106	21.2	2.12	0.92	1.04
1000 Hz	44	6.41	94	50.1	63.5	12.6	1.26	0.55	0.62
2000 Hz	22	3.21	47	25.1	31.8	6.35	0.64	0.27	0.31
3000 Hz	14.7	2.14	31.4	16.7	21.2	4.24	0.42	0.18	0.21

NOTICE:

All C Values are in nf
All L Values are in H

Figure 72 . Circuit Diagram of the Low-Pass Filter Section of the Suvag I, Serial No. 079 Auditory Training Unit.

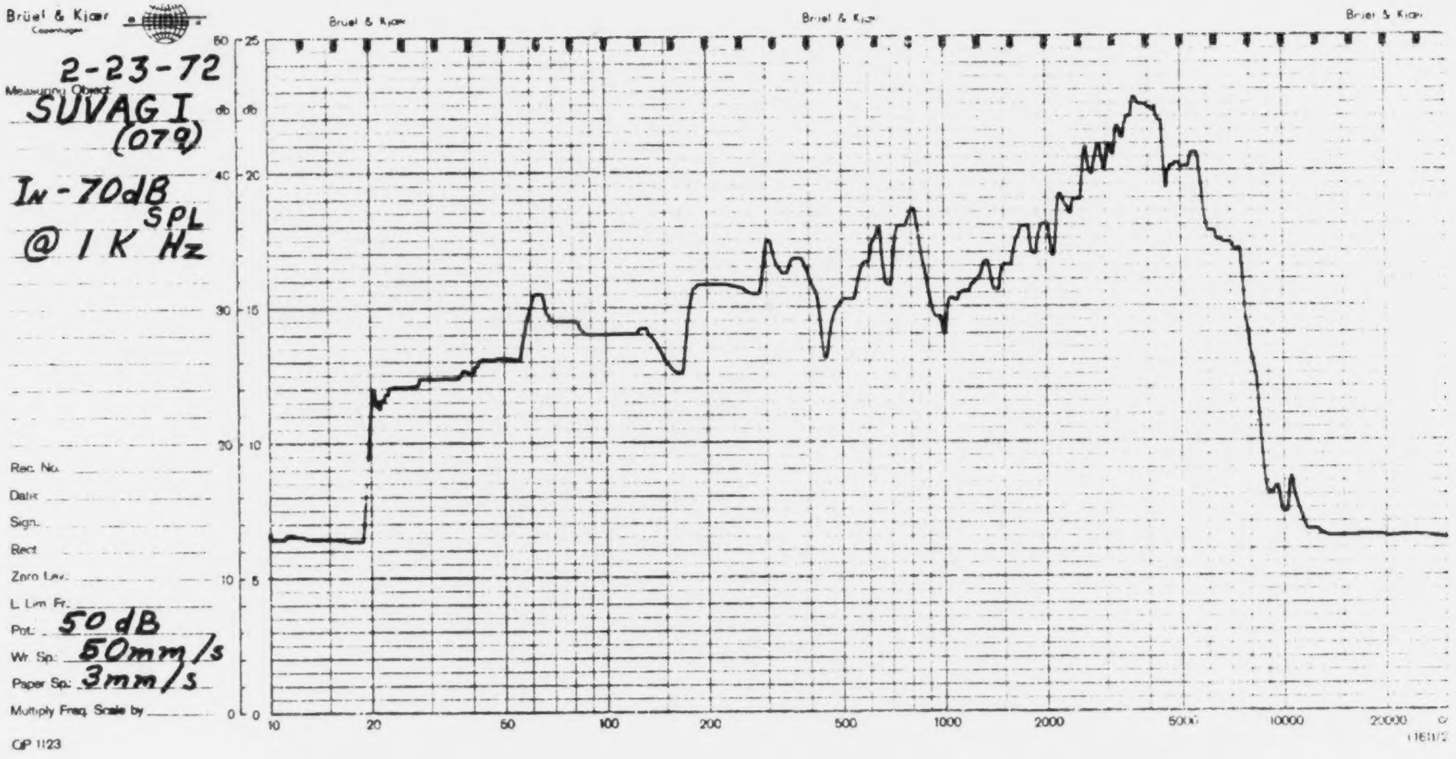


Figure 73 . Frequency Response of the Suvag I, Serial No. 079
(Acoustical Input and Electrical Output)

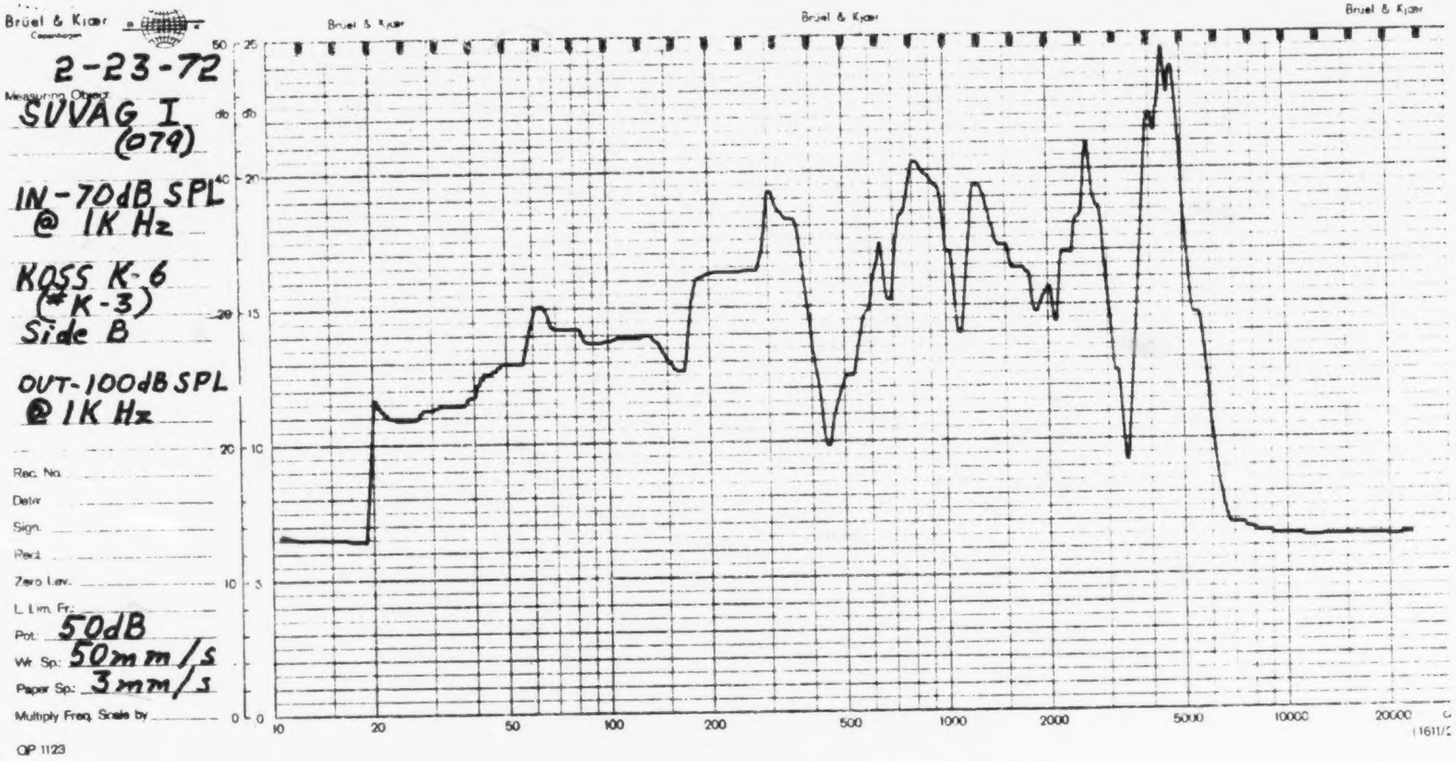


Figure 74 . Frequency Response of the Suvag I, Serial No. 079
(Acoustical Input and Acoustical Output)

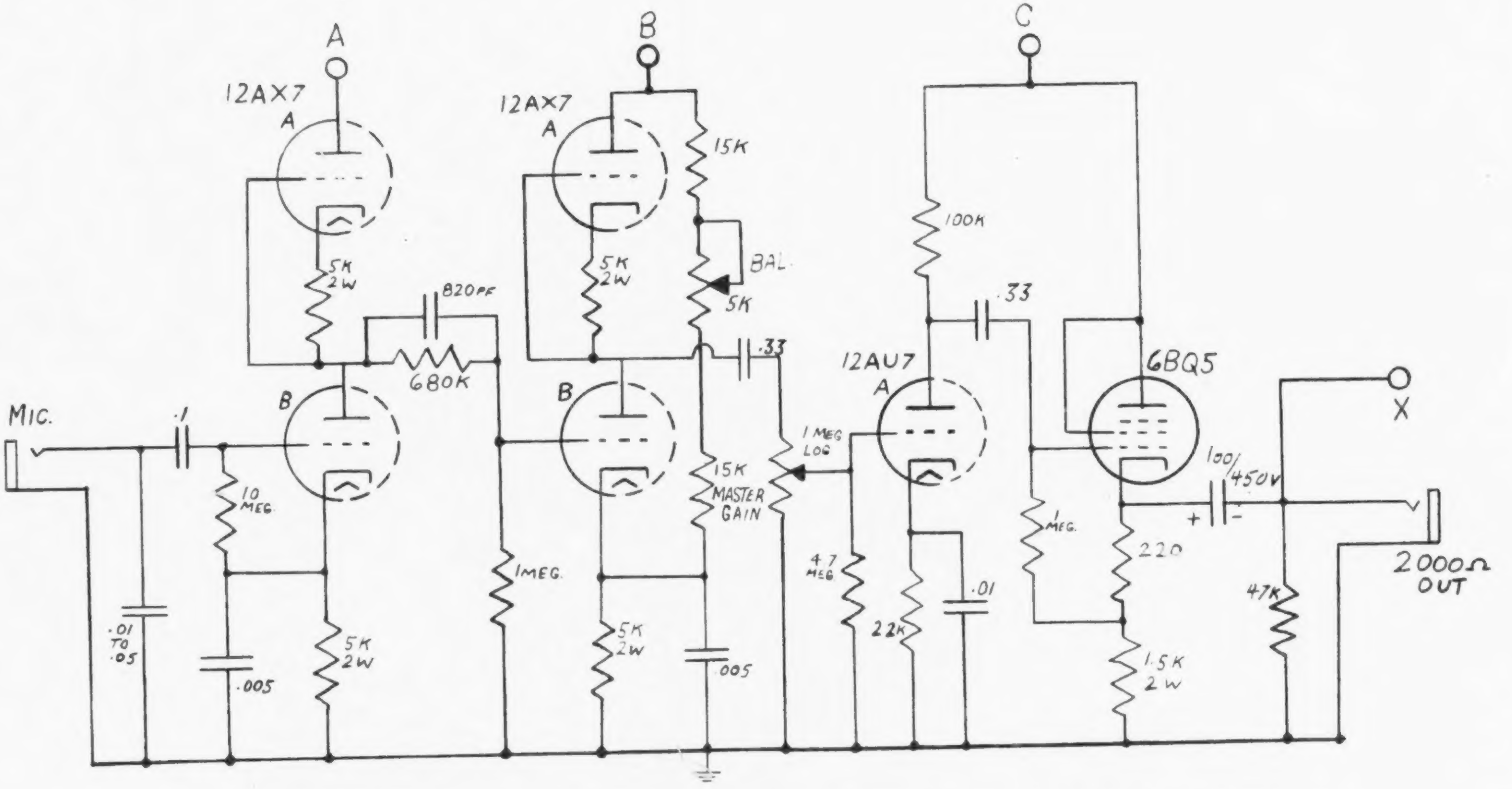

A
B
C
X
12AX7
A
B
12AX7
A
B
12AU7
A
6BQ5
MIC.
.1
10 MEG.
.01 TO .05
.005
5K 2W
5K 2W
820PF
680K
1MEG.
5K 2W
5K 2W
15K
BAL.
5K
.33
15K MASTER GAIN
.005
1 MEG LOG
4.7 MEG
22K
.01
100K
.33
1 MEG.
220
1.5K 2W
100/450V
+
-
47K
2000Ω OUT

Figure 75 . Circuit Diagram of the Pre-Amplifier, Attenuator and Driver Amplifier of the Suvag I, Serial No. G-125 Auditory Training Unit.

limited. Distortion, due to component variation will occur in the second stage as a result of its critical bias point. Clipping will also occur in the last two stages if the attenuator is adjusted too high.

The power amplifier shown in Figure 76 is designed for wide frequency amplification. A push-pull stage is coupled to the output through an exceptionally-large transformer. The unusual size of this transformer provides effective coupling at low frequencies. A choice of output impedances is provided; these values vary for different models.

The last section of the Suvag I is the power supply, as seen in Figure 77 . This portion of the unit is easily understood; however, the OB2 voltage regulators have caused some maintenance problems.

The block diagram for the Suvag I remains the same for each unit. The model is number one. The serial numbers or production line numbers identify the number of units that have been produced. For different serial numbers there are design changes to up-date the unit and provide a more effective acoustic signal for the classroom. As a result, specifications for a particular serial number pertain to that particular unit, and may or may not pertain to other units. However, in general, the specifications are similar.

Warren Auditory Training Unit

The Warren auditory training unit model T-2 has been chosen to represent the more conventional amplification unit. The major differences between this unit and the Suvag I are its narrower frequency response and its gated compression circuit. A block diagram may be viewed in Figure 78, with schematic diagrams of each section to follow in Figures 81 through 84.

All measurements were obtained under the following conditions: (a) a .3 ohm load on the group output terminal, (b) a 20 ohm load on the speaker output terminal, and (c) the gated compression circuit not activated. The following is a list of specifications and frequency responses:

(1)	input sensitivity	1.8 mVRMS for rated output
(2)	group output voltage	1.9 VRMS into a .3 ohm load
(3)	group output power	12 watts RMS into a .3 ohm load
(4)	group output impedance	.3 ohm
(5)	speaker output voltage	2.5 VRMS into a 20 ohm load
(6)	speaker output power	.31 watt RMS into 20 ohm load
(7)	speaker output impedance	20 ohms
(8)	signal to noise ratio	57 dB
(9)	frequency responses	
	electrical input vs electrical output	(see Figure 3)
	electrical input vs acoustical output	" " 7
	acoustical input vs electrical output	" " 79
	acoustical input vs acoustical output	" " 80

Though the Warren unit uses a single, high impedance crystal microphone, it is not necessary to have as high an input impedance as the Suvag I. While the low impedance will hamper the low frequencies, it must be remembered that one of the main objectives of the Warren unit is to attenuate low frequencies. As seen in Figure 81 , a schematic diagram of the pre-amplifier, a 1 meg ohm resistor is used to determine the input impedance. This circuit also shows a phono pick-up and three microphone inputs, only one of which is used in the experimental design of our classrooms.

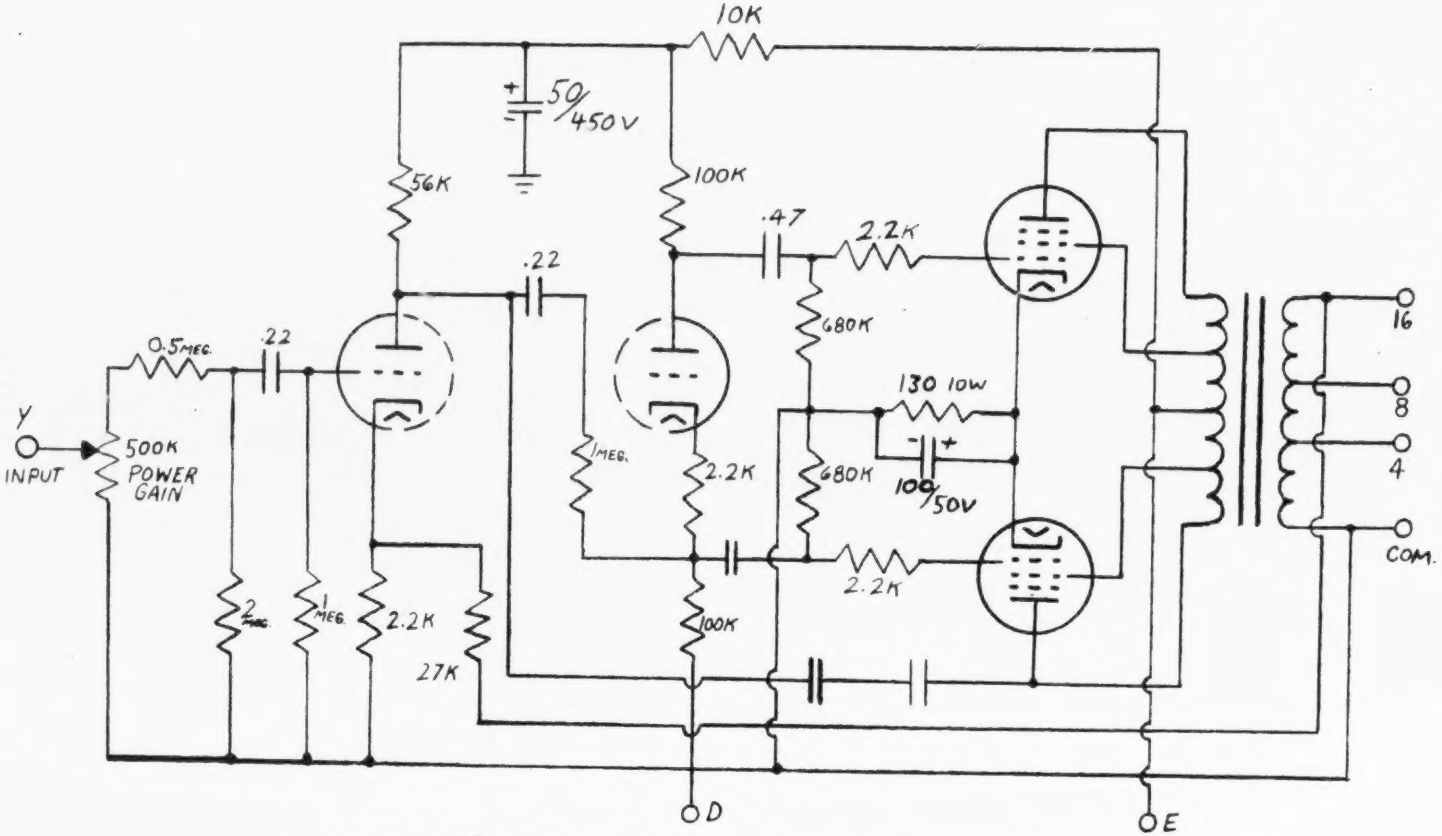

10K
50/450V
56K
100K
.47
2.2K
.22
0.5MEG.
.22
Y
INPUT
500K
POWER
GAIN
1MEG.
2.2K
680K
130 10W
680K
100/50V
2.2K
2MEG.
1MEG.
2.2K
27K
100K
16
8
4
COM.
D
E

Figure 76 . Circuit Diagram of the Attenuator and Power Amplifier of the Suvag I, Serial No. G-125 Auditory Training Unit.

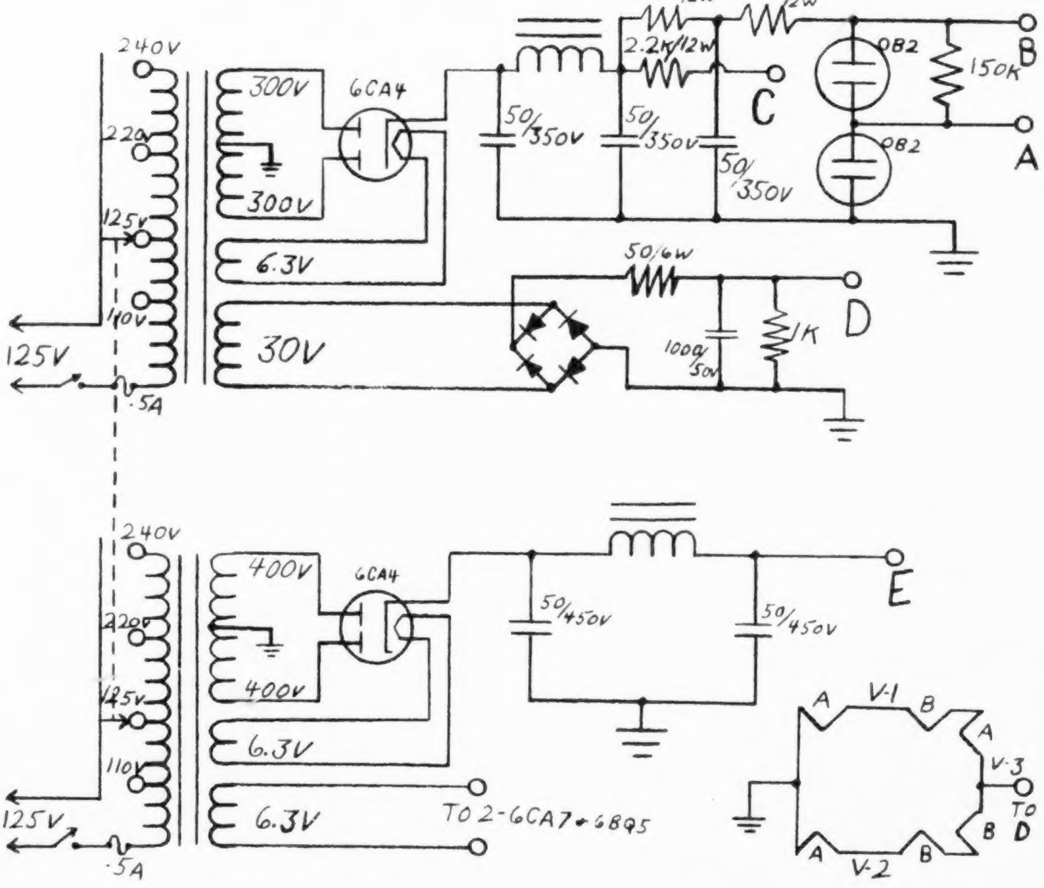

240V
220V
125V
110V
125V
.5A
300V
300V
6CA4
6.3V
30V
50/350V
50/350V
50/350V
2.7K/2W
2.2K/12W
5.6K/2W
OB2
OB2
150K
B
A
C
50/6W
1000/50V
1K
D
240V
220V
125V
110V
125V
.5A
400V
400V
6CA4
6.3V
6.3V
TO 2-6CA7 + 6BQ5
50/450V
50/450V
E
A
V-1
B
A
V-3
TO
D
B
A
V-2
B

Figure 77 . Circuit Diagram of the Power Supply of the Suvag I, Serial No. G-125 Auditory Training Unit.

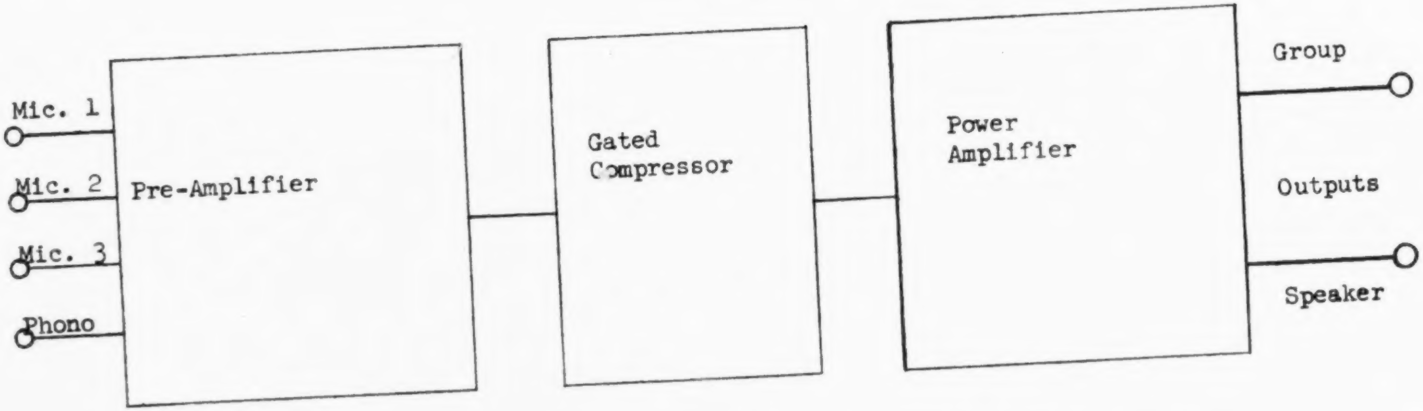

Mic. 1
Mic. 2
Mic. 3
Phono
Pre-Amplifier
Gated Compressor
Power Amplifier
Group
Outputs
Speaker

Figure 78 . Block Diagram of the Warren Model T-2 Auditory Training Unit.

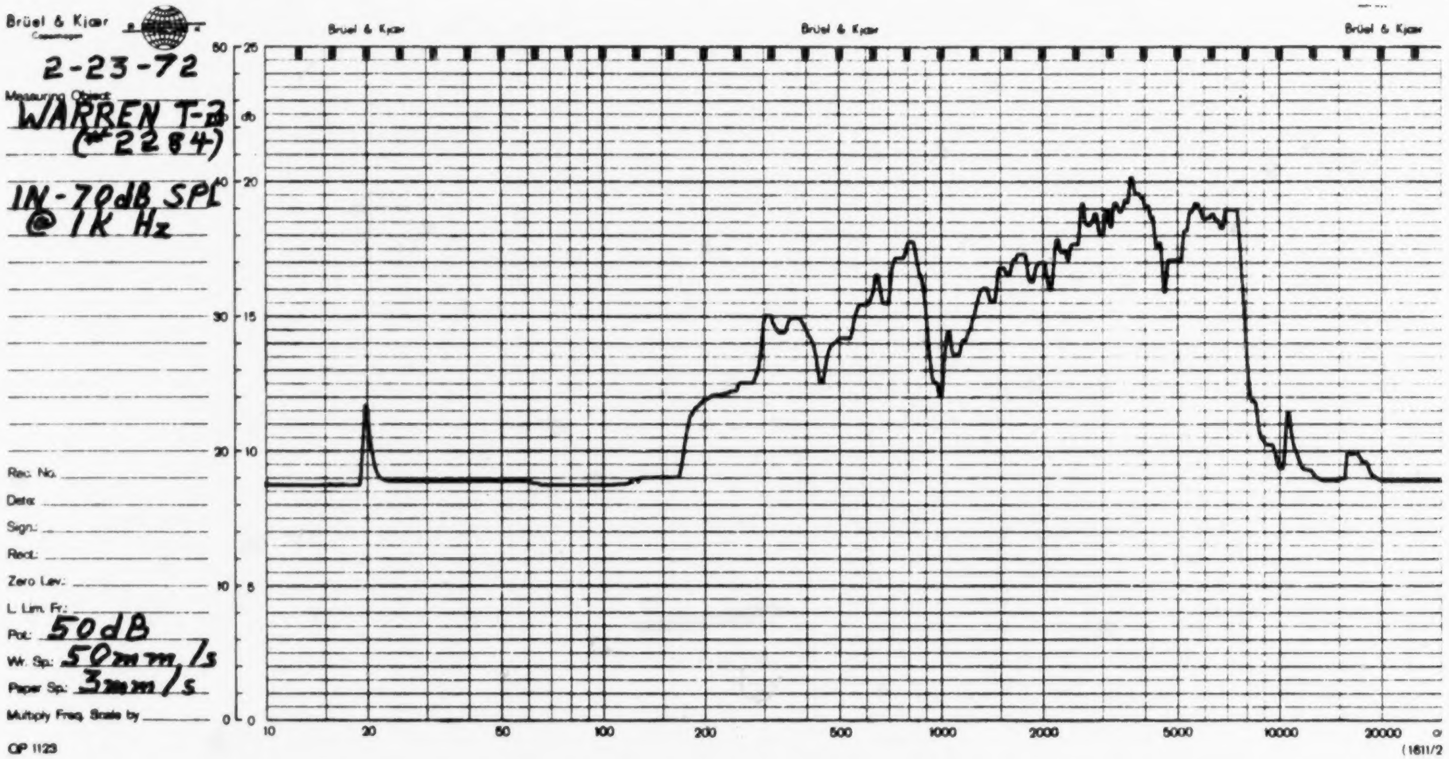


Figure 79 . Frequency Response of the Warren Model T-2 (Acoustical Input and Electrical Output)

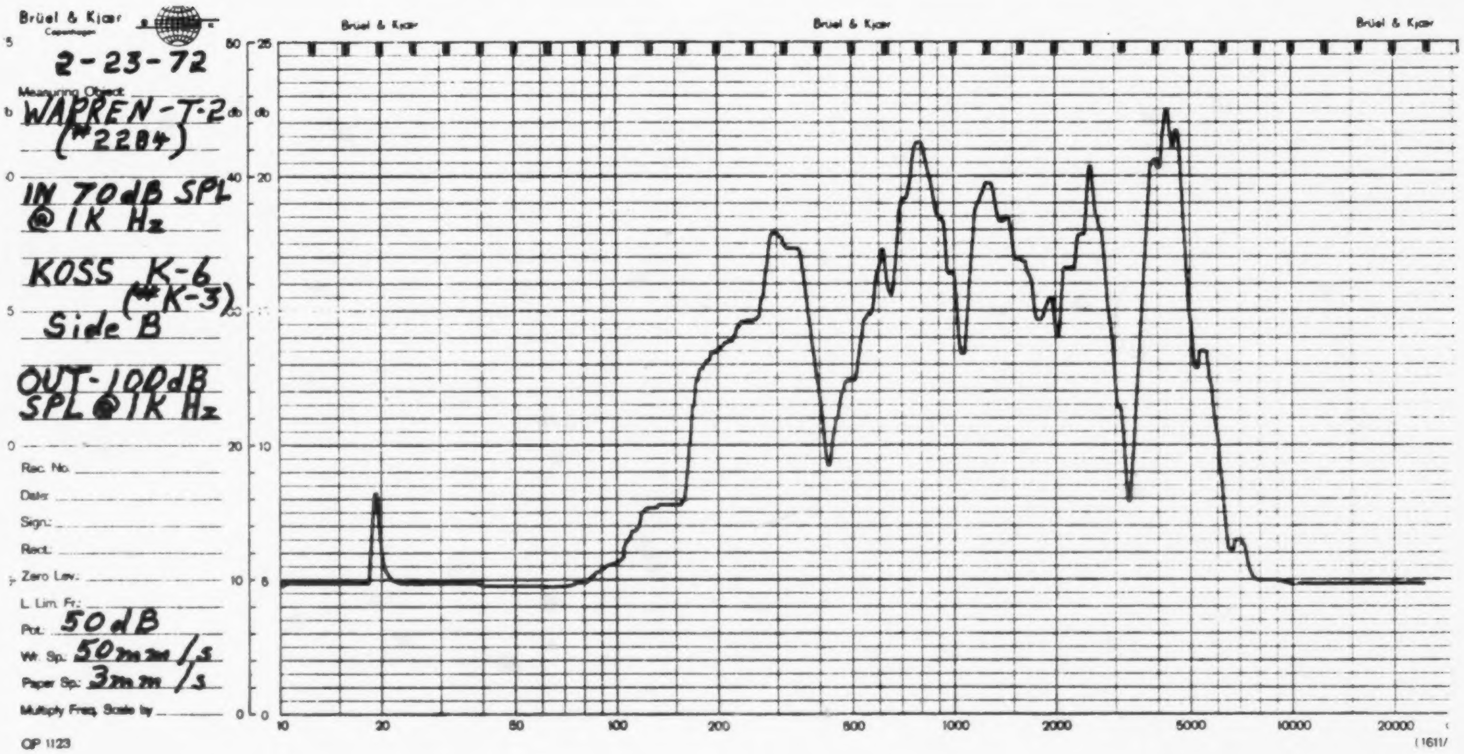


Figure 80. Frequency Response of the Warren Model T-2
(Acoustical Input and Acoustical Output)

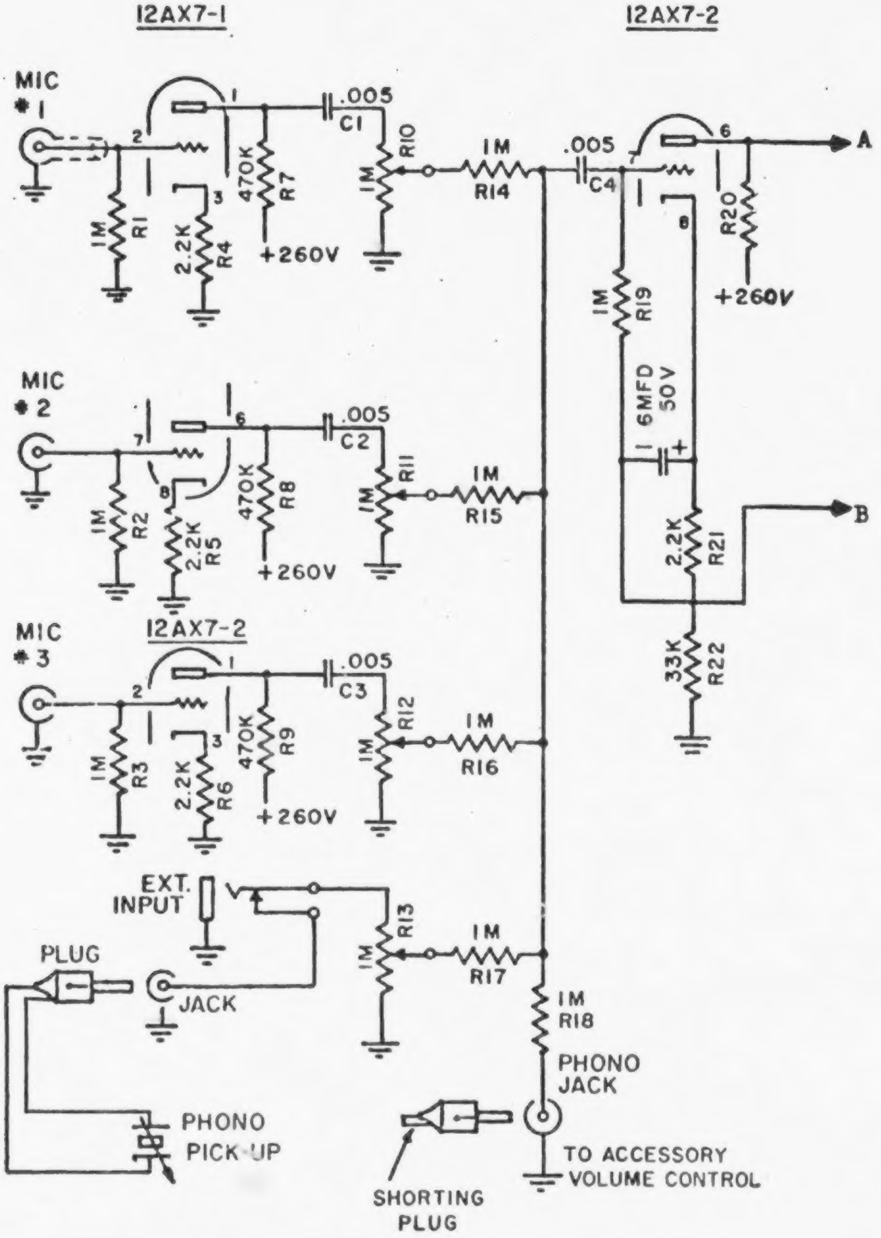

12AX7-1
12AX7-2
MIC #1
MIC #2
MIC #3
12AX7-2
.005 C1
.005 C2
.005 C3
.005 C4
1M R1
1M R2
1M R3
2.2K R4
2.2K R5
2.2K R6
470K R7
470K R8
470K R9
1M R10
1M R11
1M R12
1M R13
1M R14
1M R15
1M R16
1M R17
1M R18
1M R19
R20
2.2K R21
33K R22
6MFD 50V
+260V
A
B
EXT. INPUT
PLUG
JACK
PHONO PICK-UP
PHONO JACK
SHORTING PLUG
TO ACCESSORY VOLUME CONTROL

Figure 81 . Circuit Diagram of the Pre-Amplifier of the Warren Model T-2.

The Gated Compression Circuit, seen in Figure 82 , is designed not as an automatic volume control, but rather as a limiter which reduces the distortion caused by clipping. Most amplifiers, the Suvag included, will clip the output signal if it is of sufficiently-high intensity. The standard method of avoiding this problem is to decrease the gain of the amplifier to a level which reduces the output to a volume below clipping. A gated compressor uses a different approach. If the output reaches 2½ dB below the clipping level, the circuit is activated and the gain is decreased. This is accomplished by biasing the rectifier 6X4-1 such that it conducts at 2½ dB below clipping and passes a signal to pins 3 and 4 of 7B8-1 and 7B8-2, which will reduce the gain to this stage. Because of the questionable effect of this principle, it is desirable not to include its effects in this experimental project. Since compression would not take place lower than the 2½ dB level below clipping, it is no more difficult to remain below compression on the Warren unit than it is to remain below clipping on the Suvag unit. A 6E5 magic eye is provided in this circuit to further assure a gain setting which would avoid the activation of compression. The output section of the unit seen in Figure 83 provides a well-regulated level for any load. There is less than a 1 dB change in level from no load to the rated output. A separate speaker winding is provided on the output transformer and is utilized to provide extra power for the bone vibrators; this winding is included in the block diagram (Figure 102) of the section of this report dealing with rack outputs.

A definite advantage of the Warren unit over the Suvag is its relatively maintenance-free operation. There are no particular components in the Warren unit which have caused chronic maintenance problems.

Suvag II

Suvag II is an auditory training unit which is intended for individual therapy use and is capable of obtaining nearly any frequency response. As seen in Figure 85, the unit is made up of a pre-amplifier, bass and treble controls, three parallel branches (direct channel, a low-pass section, and a high-pass section) and a power amplifier. A schematic diagram for serial number 020 is seen in Figures 86 through 92. The circuits and specifications vary from serial number to serial number; however, the block diagram is similar for all Suvag II units.

The bass and treble controls may be used to shape a crude filter response or enhance the more discrete filter settings. A frequency response of these controls set for full boost or full cut may be seen in Figure 93 . A flatter response may be obtained by decreasing these controls toward the center position.

The first channel of the parallel branch, known as the low-pass filter section, consists of low-pass filters, high-pass filters, and peaking filters. Each individual LC low-pass filter is equipped with a corresponding RC high-pass filter. A choice of sharp or gentle roll-offs may be selected for any of the low-pass filters. For this serial number the sharp roll-off is 30 dB/octave and the gentle roll-off is 18 dB/octave; however, roll-off may vary from unit to unit due to circuit changes. The accompanying high-pass filter is adjusted so that the slope to the left of the break frequency may be adjusted from 0 to 18 dB/octave in discrete 6 dB steps. The peaking filter is an LC resonant circuit which can be switched to specific center frequencies. On some units the sharpness or the Q of the filter may also be adjusted. Actual frequency responses of these various filter settings are included in Figures 94 through 96.

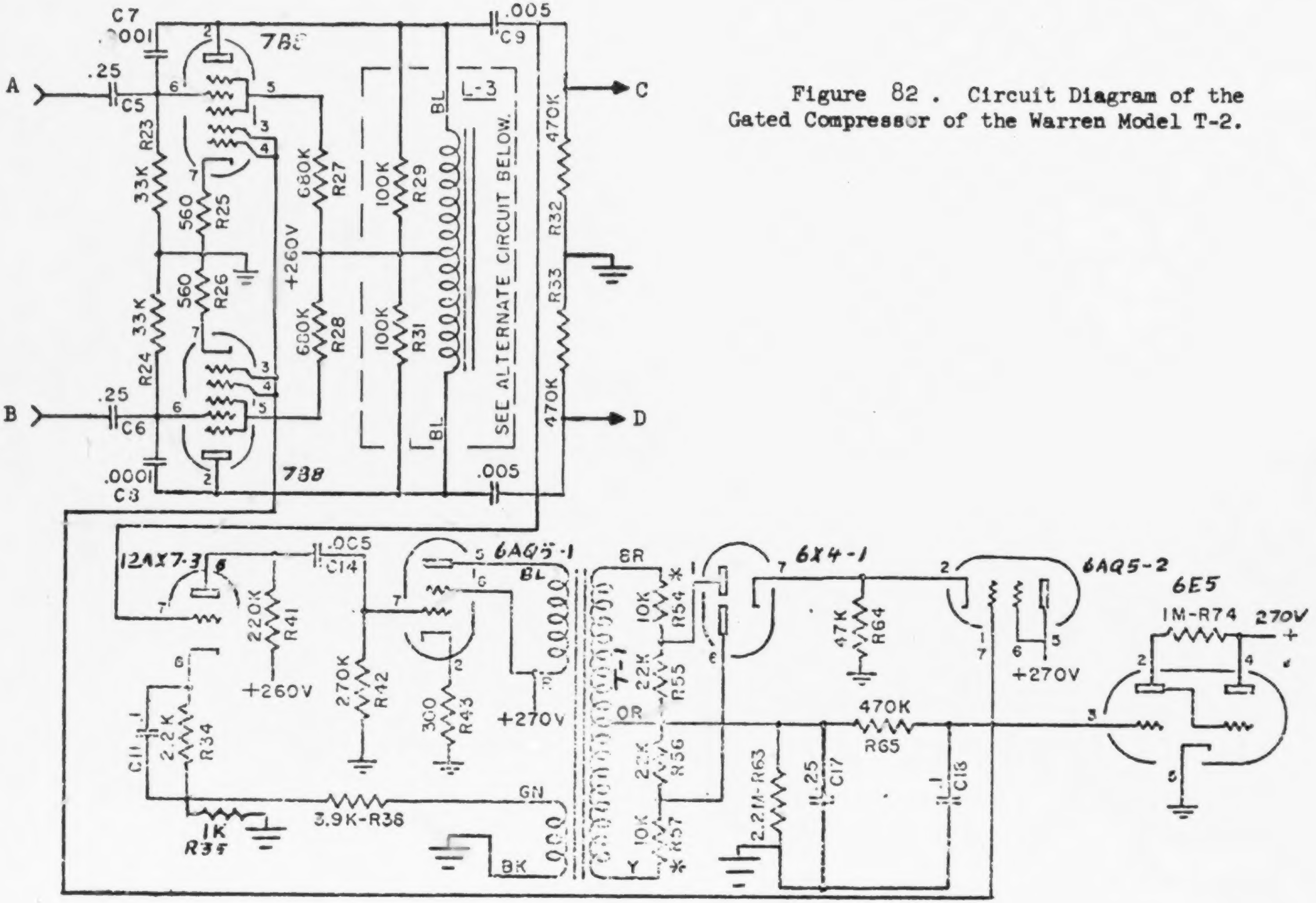

A
B
C
D
C7
.0001
.25
C5
C6
C8
.0001
7B8
7B8
R23
33K
R24
33K
560
R25
560
R26
680K
R27
680K
R28
+260V
100K
R29
100K
R31
BL
BL
L-3
SEE ALTERNATE CIRCUIT BELOW.
.005
C9
.005
470K
R32
R33
470K
12AX7-3
.005
C14
220K
R41
+260V
270K
R42
6AQ5-1
BL
300
R43
+270V
C11
2.2K
R34
1K
R35
3.9K-R36
GN
BK
8R
T-1
10K
R54
22K
R55
OR
22K
R56
10K
R57
Y
6X4-1
47K
R64
2.2M-R63
.25
C17
470K
R65
C18
6AQ5-2
+270V
6E5
1M-R74
270V
+

Figure 82 . Circuit Diagram of the Gated Compressor of the Warren Model T-2.

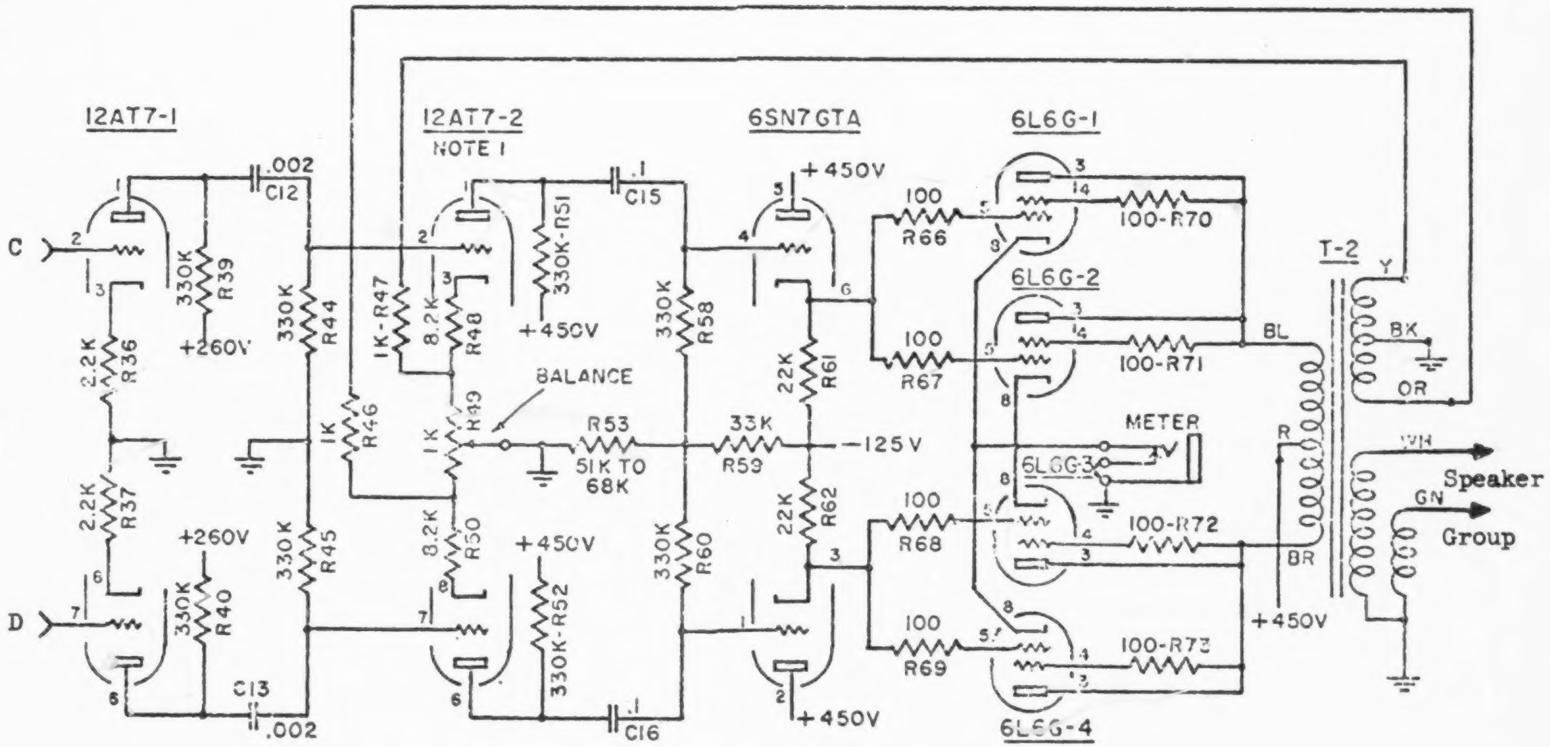

12AT7-1
12AT7-2
NOTE 1
6SN7GTA
6L6G-1
6L6G-2
6L6G-3
6L6G-4
T-2
C
D
.002
C12
C13
.1
C15
C16
330K
R39
R40
+260V
2.2K
R36
R37
330K
R44
R45
1K
R46
1K-R47
8.2K
R48
R49
R50
BALANCE
330K-R51
330K-R52
+450V
R53
51K TO
68K
330K
R58
R60
33K
R59
22K
R61
R62
-125V
100
R66
R67
R68
R69
100-R70
100-R71
100-R72
100-R73
METER
BL
BR
R
Y
BK
OR
WH
GN
Speaker
Group

Figure 83. Circuit Diagram of the Power Amplifier of the Warren Model T-2.

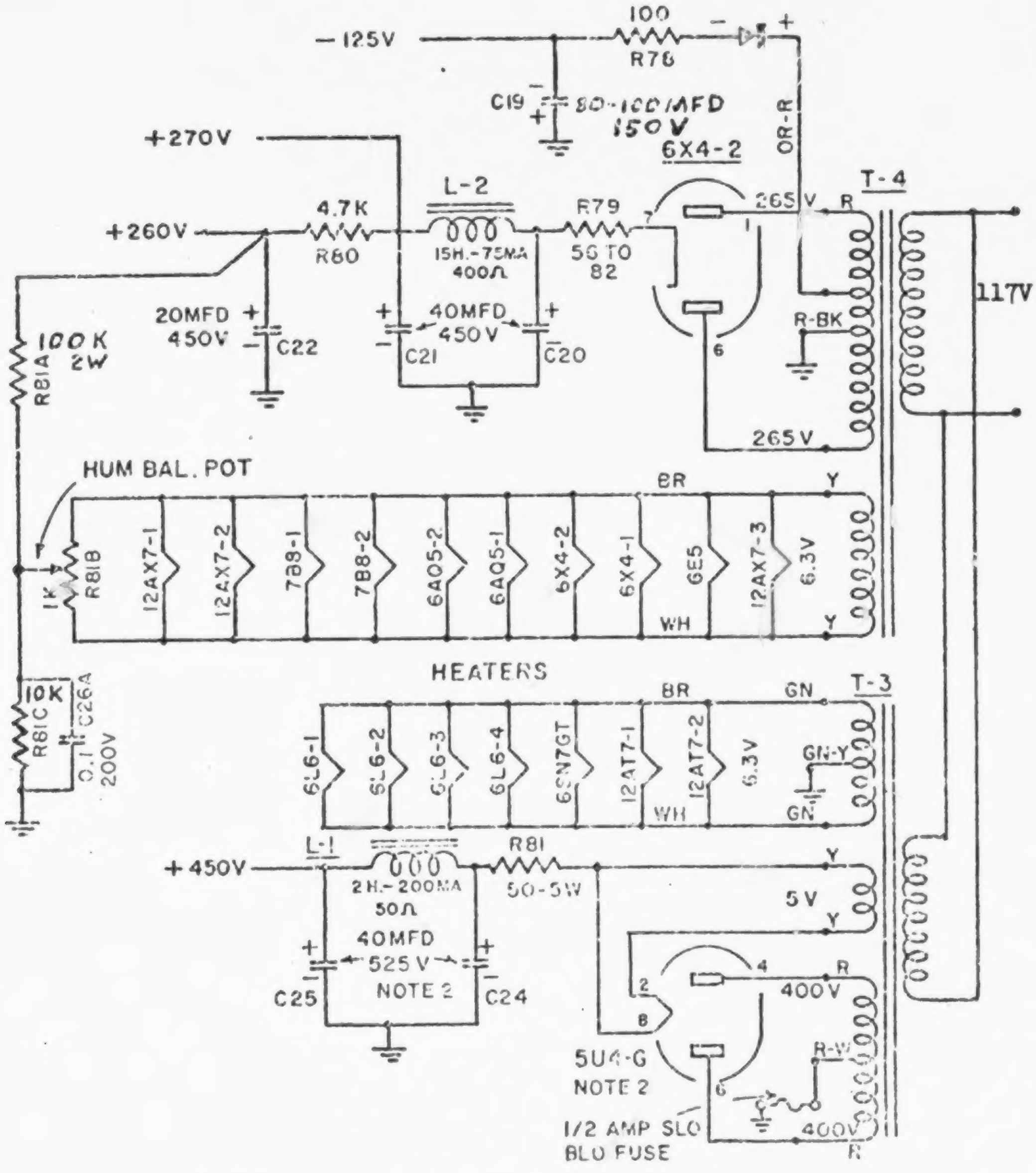

−125V
100
R78
C19
80-100 MFD
150V
OR-R
6X4-2
+270V
+260V
4.7K
R80
L-2
15H.-75MA
400Ω
R79
56 TO
82
265V
R
T-4
117V
R-BK
6
265V
20MFD
450V
C22
40MFD
450V
C21
C20
100K
2W
R81A
HUM BAL. POT
1K
R81B
12AX7-1
12AX7-2
7B8-1
7B8-2
6AQ5-2
6AQ5-1
6X4-2
6X4-1
6E5
12AX7-3
6.3V
BR
Y
WH
Y
HEATERS
10K
R81C
C26A
0.1
200V
6L6-1
6L6-2
6L6-3
6L6-4
6SN7GT
12AT7-1
12AT7-2
6.3V
BR
GN
T-3
GN-Y
WH
GN
+450V
L-1
2H.-200MA
50Ω
R81
50-5W
Y
5V
Y
40MFD
525V
NOTE 2
C25
C24
2
4
8
6
R
400V
R-W
5U4-G
NOTE 2
1/2 AMP SLO
BLO FUSE
400V
R

Figure 84 . Circuit Diagram of the Power Supply of the Warren Model T-2.

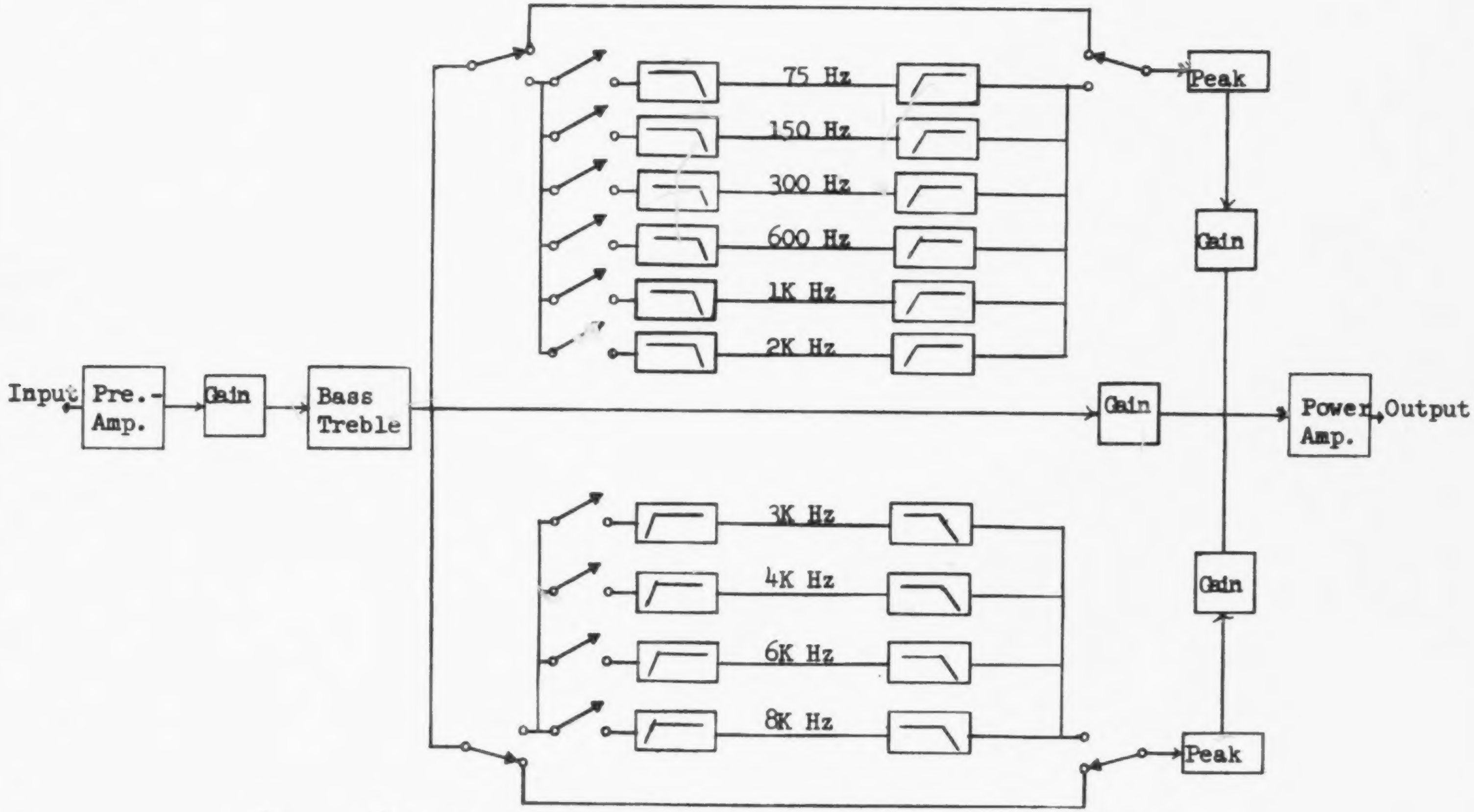

Input
Pre.-Amp.
Gain
Bass Treble
75 Hz
150 Hz
300 Hz
600 Hz
1K Hz
2K Hz
3K Hz
4K Hz
6K Hz
8K Hz
Peak
Gain
Gain
Gain
Peak
Power Amp.
Output

Figure 85 . Block Diagram of the Suvag II Auditory Training Unit.

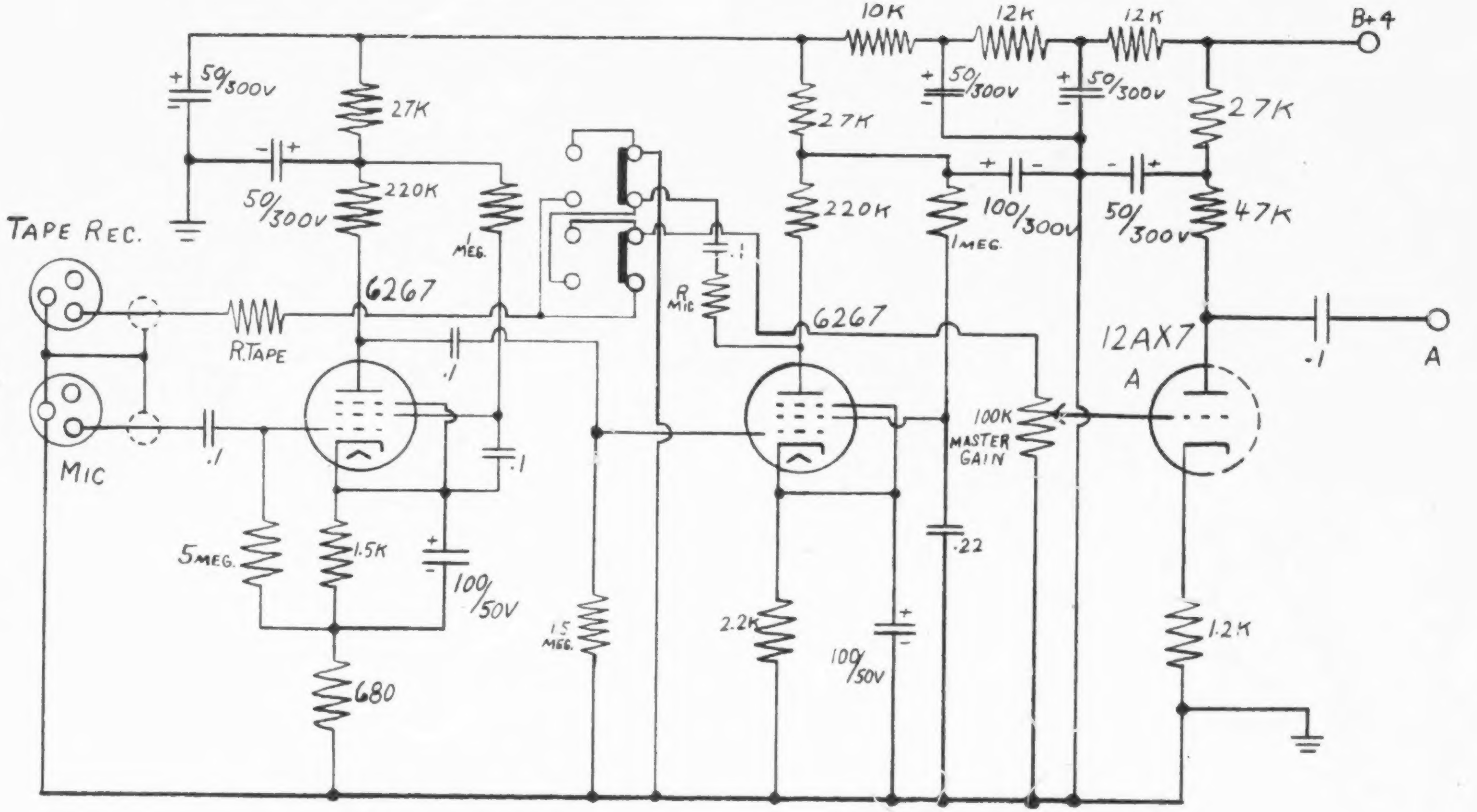

10K
12K
12K
B+4
50/300V
27K
50/300V
50/300V
27K
27K
50/300V
220K
1 MEG.
220K
100/300V
1MEG.
50/300V
47K
TAPE REC.
6267
R.TAPE
.1
R MIC
.1
6267
12AX7
A
.1
A
.1
MIC
100K MASTER GAIN
.1
5MEG.
1.5K
100/50V
.22
1.5 MEG.
2.2K
100/50V
1.2K
680

Figure 86. Circuit Diagram of the Pre-Amplifier and Master Gain Control of the Suvag II, Serial No. 043.

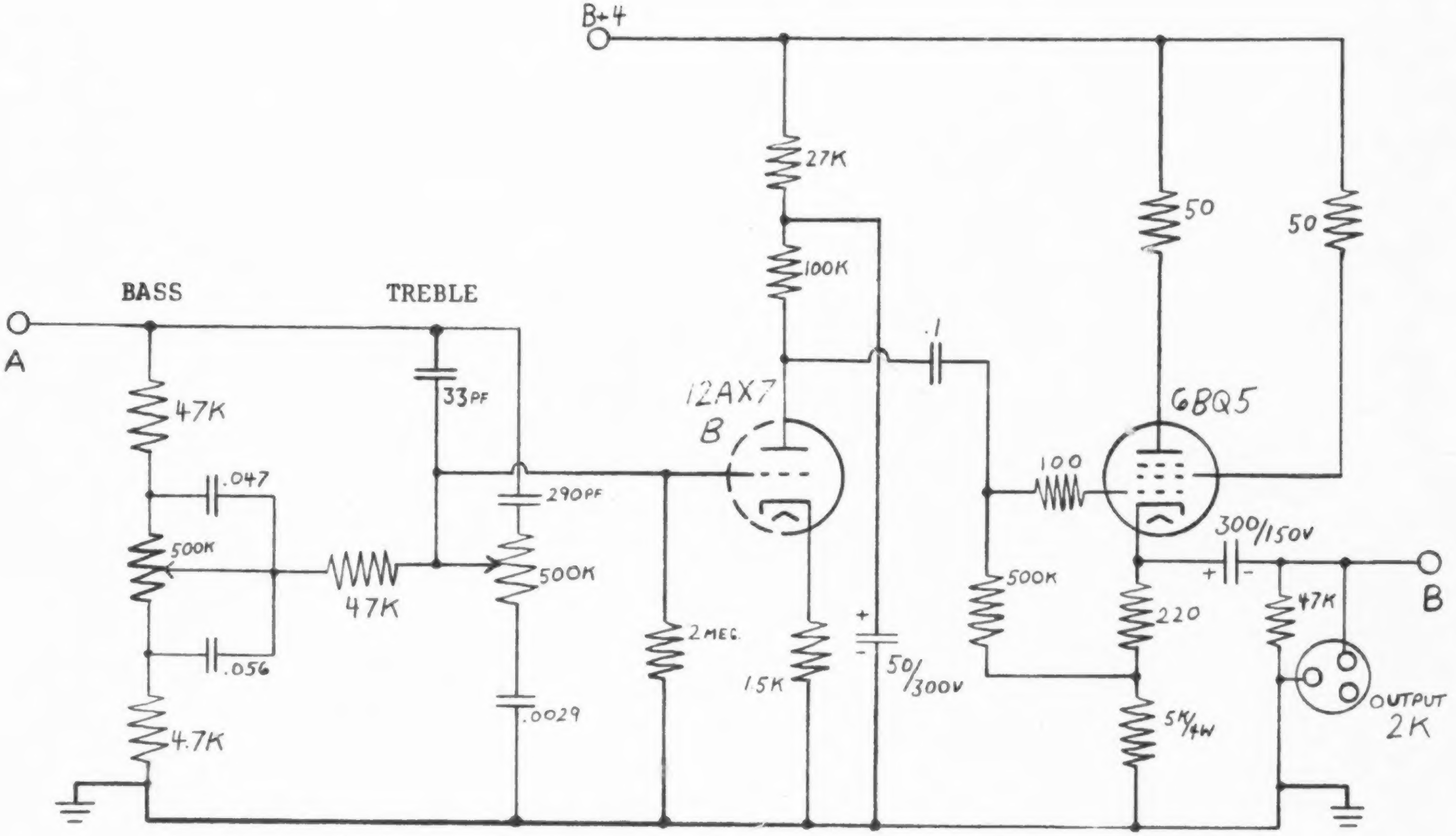

B+4
A
BASS
TREBLE
47K
.047
500K
.056
4.7K
47K
33PF
290PF
500K
.0029
2MEG.
12AX7
B
27K
100K
1.5K
50/300V
.1
500K
100
6BQ5
50
50
300/150V
220
5K/4W
47K
B
OUTPUT
2K

Figure 87 . Circuit Diagram of the Bass and Treble Control of the Suvag II, Serial No. 043.

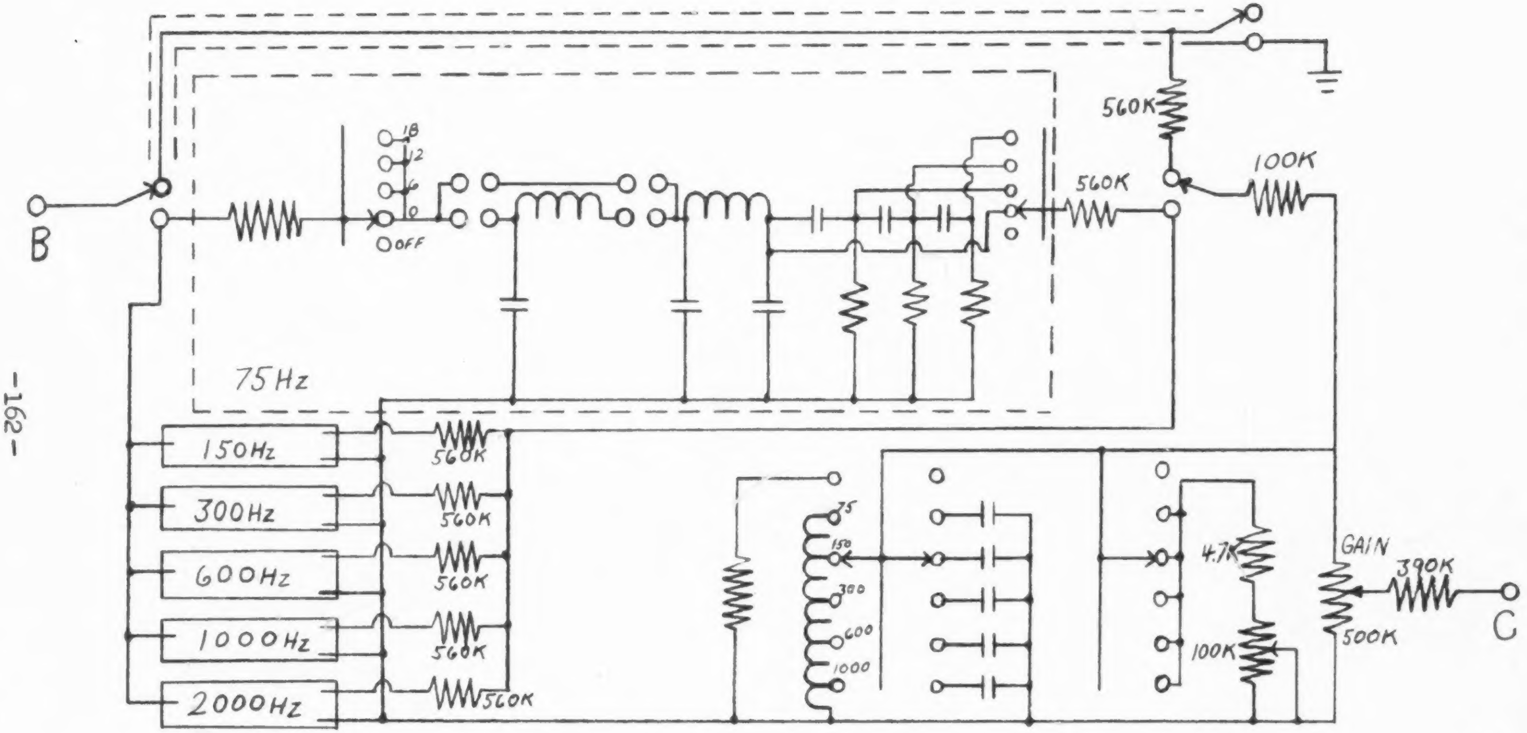

B
C
75 Hz
18
12
6
0
OFF
560K
100K
560K
150Hz
300Hz
600Hz
1000Hz
2000Hz
560K
560K
560K
560K
560K
75
150
300
600
1000
4.7K
100K
GAIN
390K
500K

Figure 88 . Circuit **Diagram** of the Low-Pass Filter Section of the Suvag II, Serial No. 043.

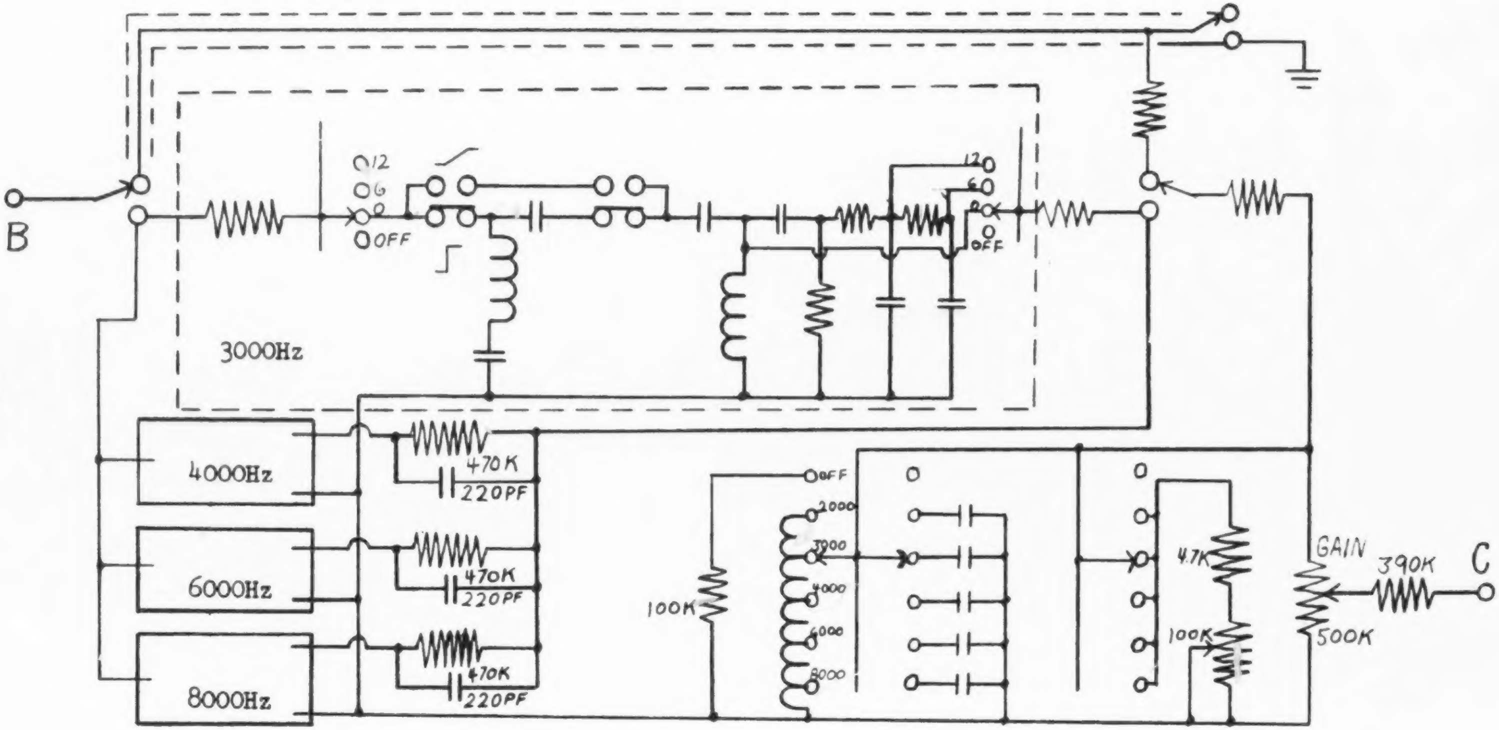

B
C
3000Hz
012
06
0
OFF
12
6
0
OFF
4000Hz
6000Hz
8000Hz
470K
220PF
470K
220PF
470K
220PF
100K
OFF
2000
3000
4000
6000
8000
4.7K
100K
GAIN
500K
390K

Figure 89. Circuit Diagram of the High-Pass Filter Section of the Suvag II, Serial No. 043.

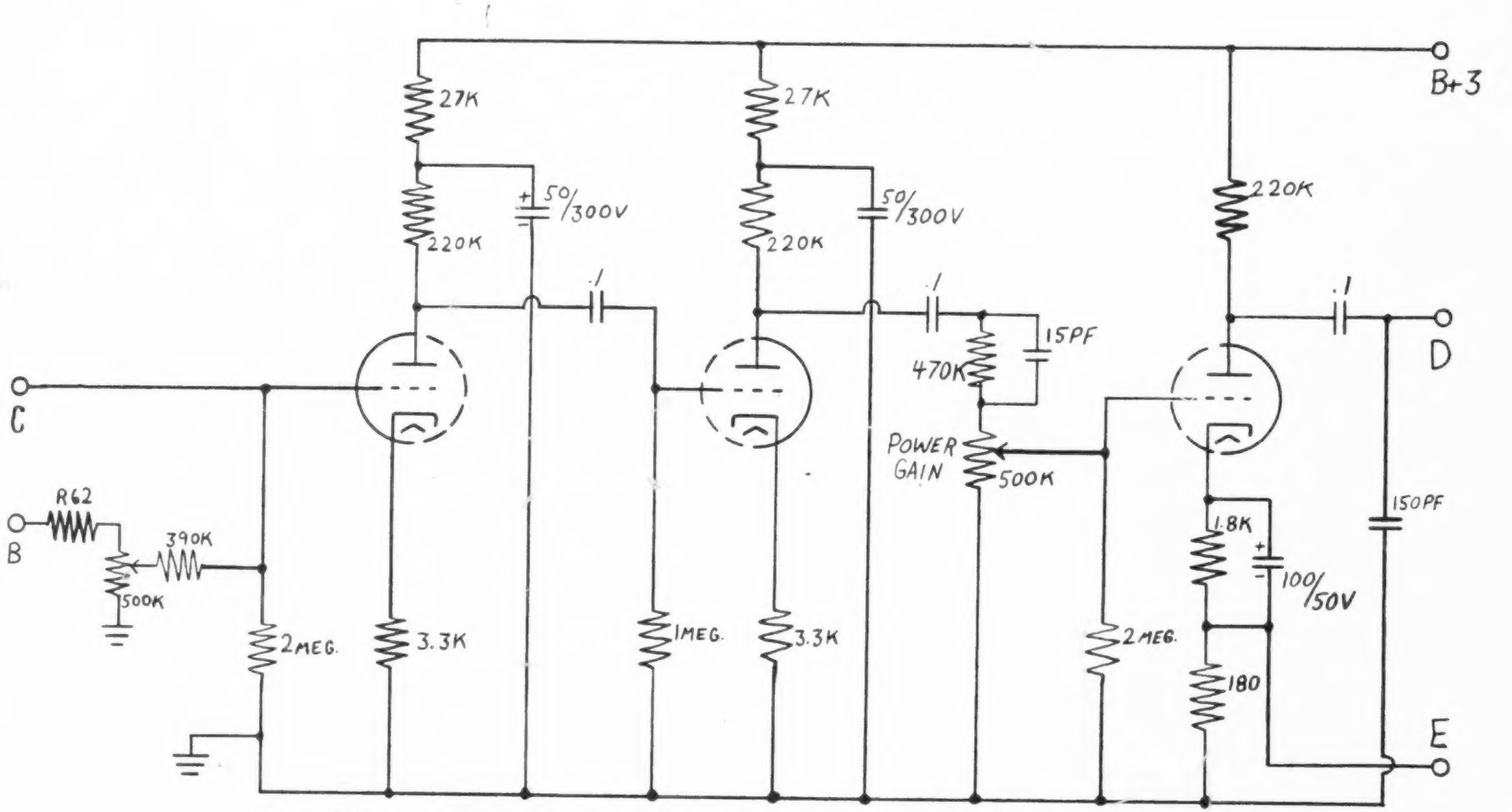

27K
220K
+
-
50/300V
.1
27K
220K
50/300V
.1
15PF
470K
POWER GAIN
500K
220K
.1
B+3
D
C
R62
B
390K
500K
2MEG.
3.3K
1MEG.
3.3K
2MEG.
1.8K
+
-
100/50V
180
150PF
E

Figure 90 . Circuit Diagram of the Driver Amplifier and Direct Channel Gain Control of the Suvag II, Serial No. 043.

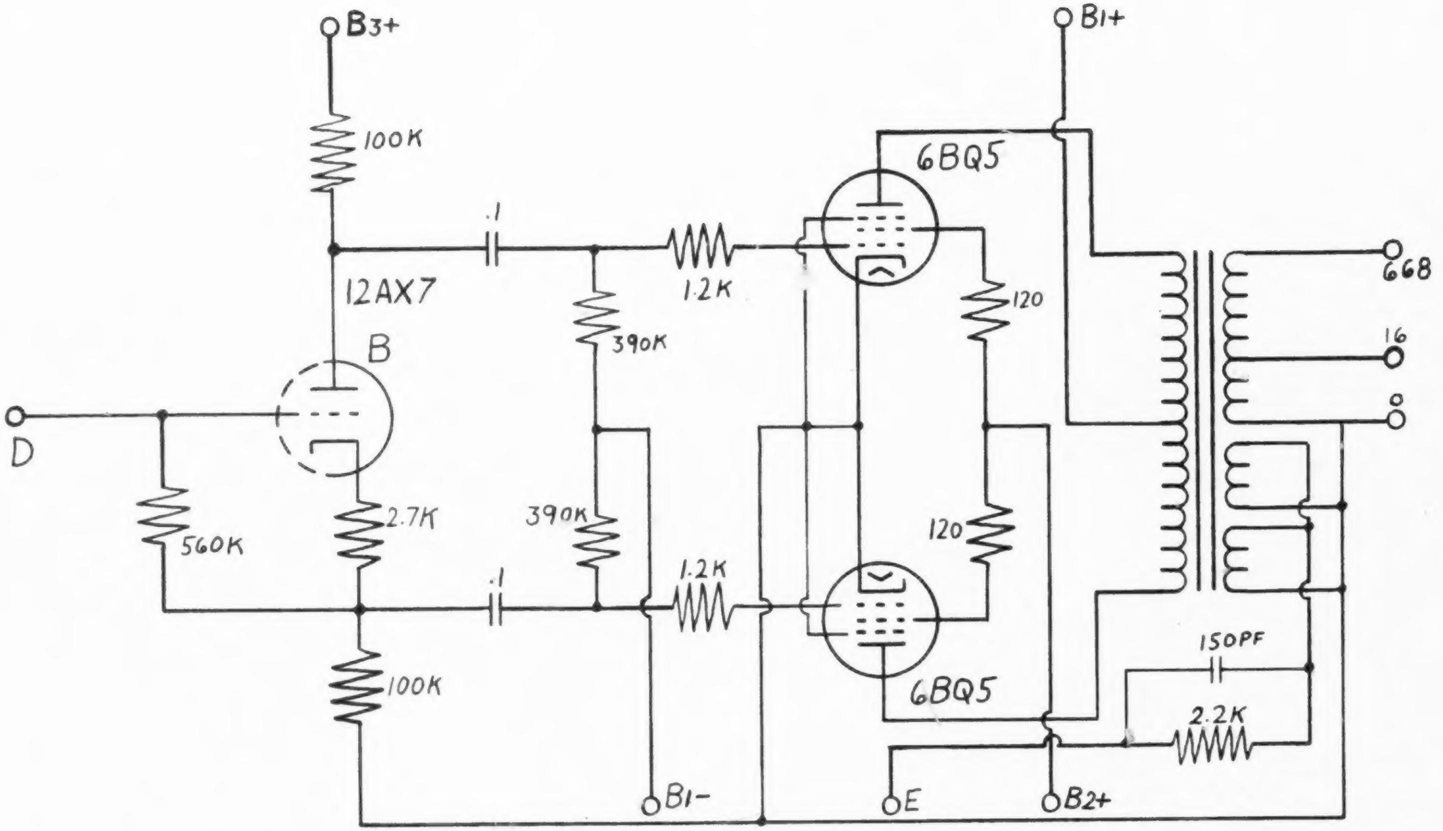

B3+
100K
.1
12AX7
B
D
560K
2.7K
100K
390K
390K
.1
1.2K
1.2K
B1-
6BQ5
6BQ5
120
120
B1+
E
B2+
150PF
2.2K
668
16
8

Figure 91 . Circuit Diagram of the Power Amplifier of the Suvag II, Serial No. 043.

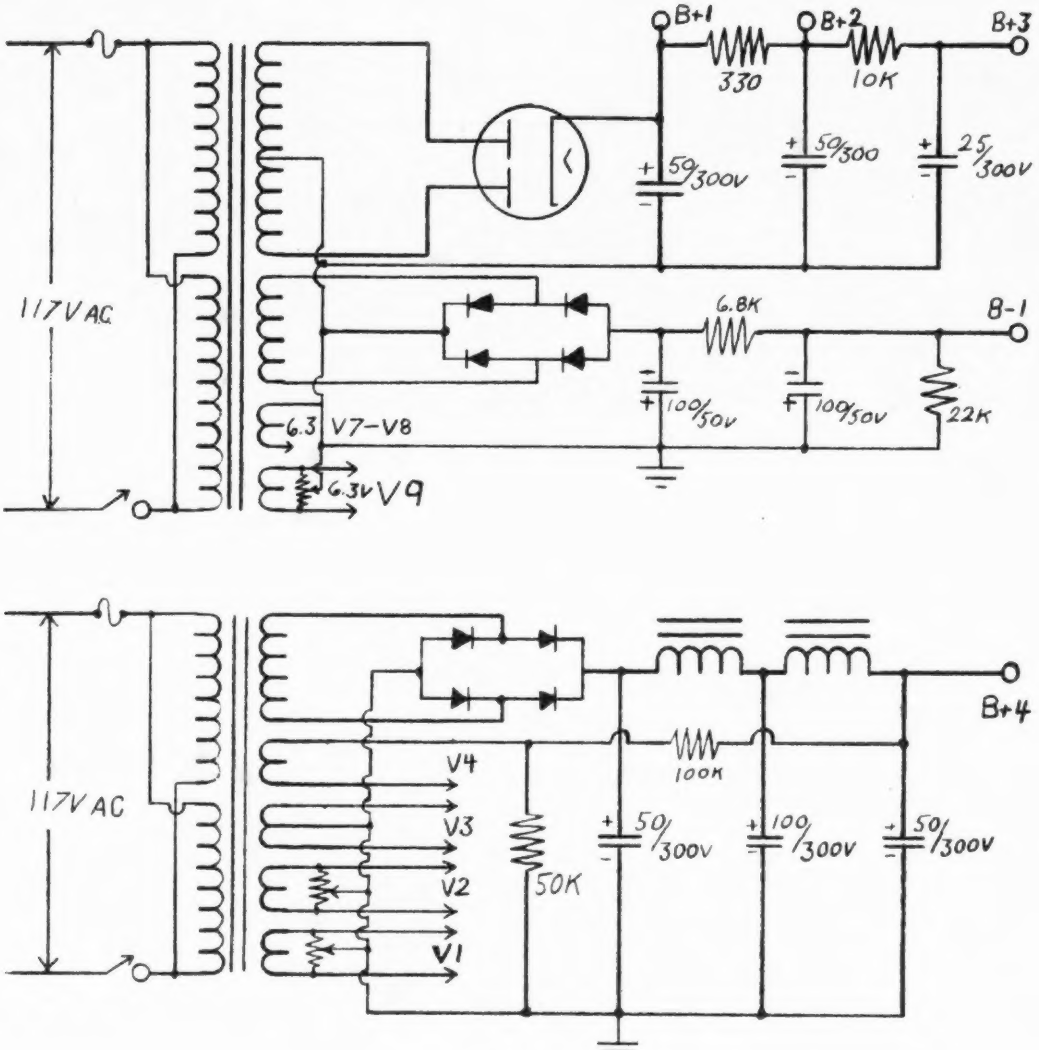
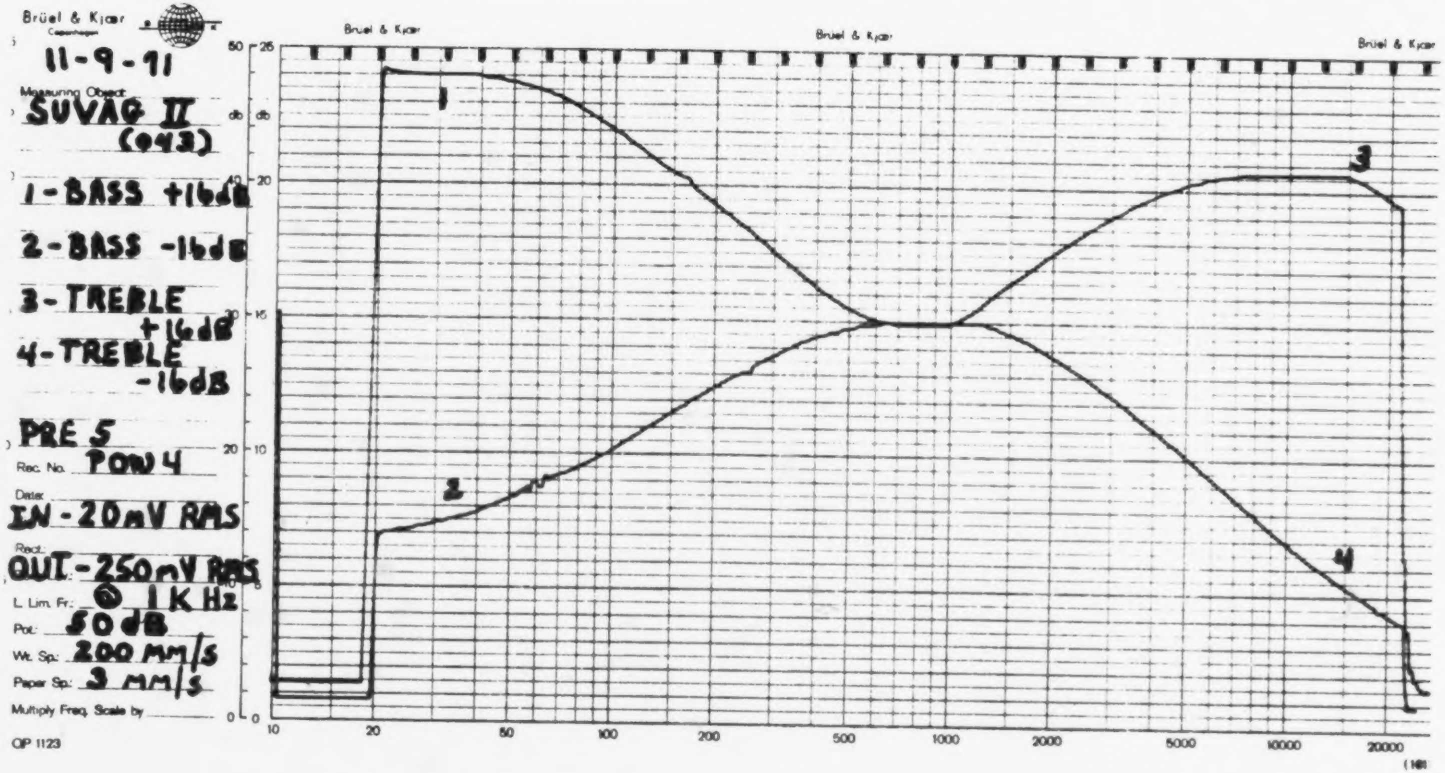

B+1
B+2
B+3
330
10K
50/300V
50/300
25/300V
117VAC
6.8K
B-1
100/50V
100/50V
22K
6.3
V7-V8
6.3V V9
B+4
100K
V4
V3
V2
V1
50K
50/300V
100/300V
50/300V
117V AC

Figure 92 . Circuit Diagram of the Power Supply of the Suvag II, Serial No. 043.



11-9-91

Measuring Object: SUVAG II (043)

1-BASS +16dB

2-BASS -16dB

3-TREBLE +16dB

4-TREBLE -16dB

PRE 5

Rec. No. POW 4

Date: IN-20mV RMS

Rect.: OUT-250mV RMS @ 1KHz

L. Lim. Fr.:

Pot.: 50dB

Wt. Sp.: 200 MM/s

Paper Sp.: 3 MM/s

Multiply Freq. Scale by

Figure 93. Frequency Response of the Suvag II, Serial No. 043
(Bass and Treble with + and - 16 dB Roll-off)

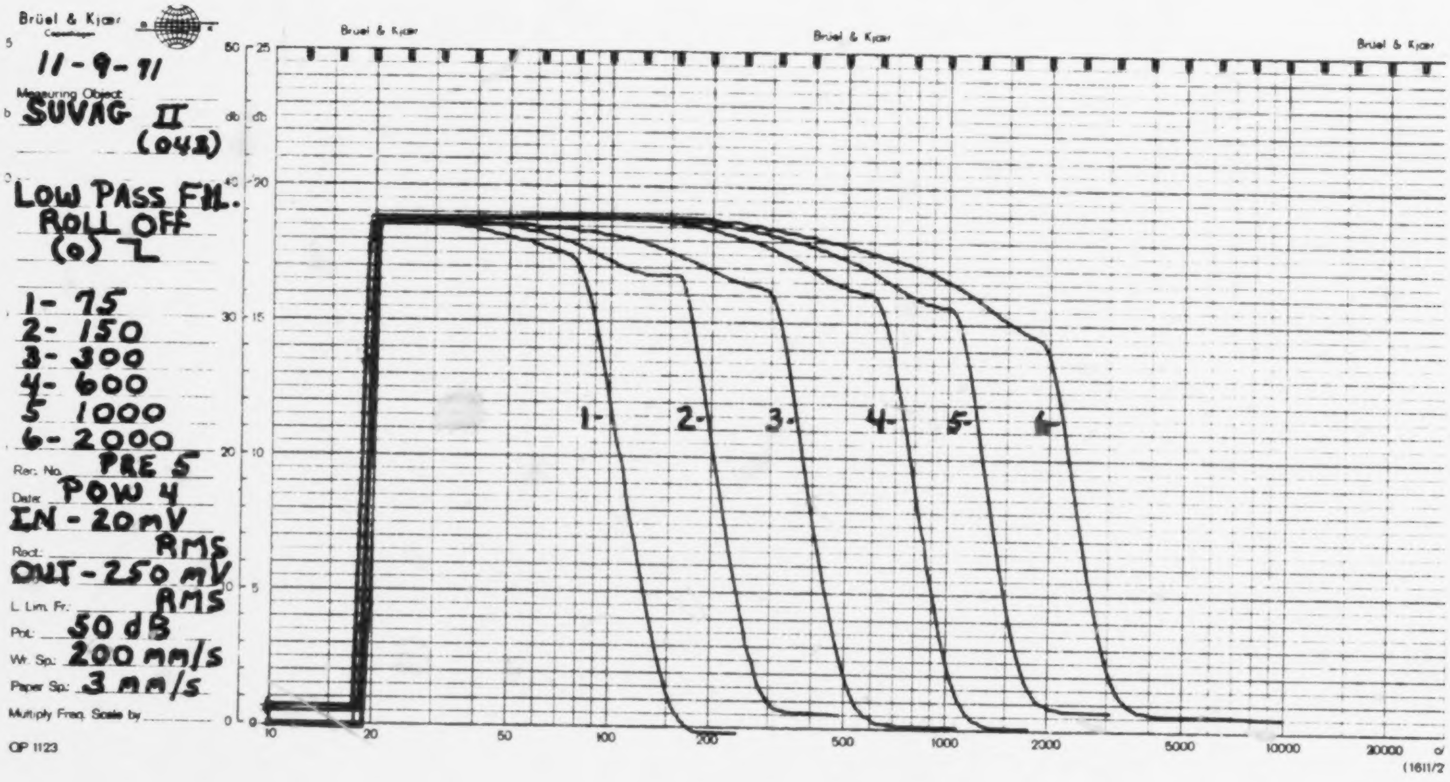


Figure 94 . Frequency Response of the Suvag II, Serial No. 043 (Low-Pass 75, 150, 300, 600, 1000 and 2000 Hz.)

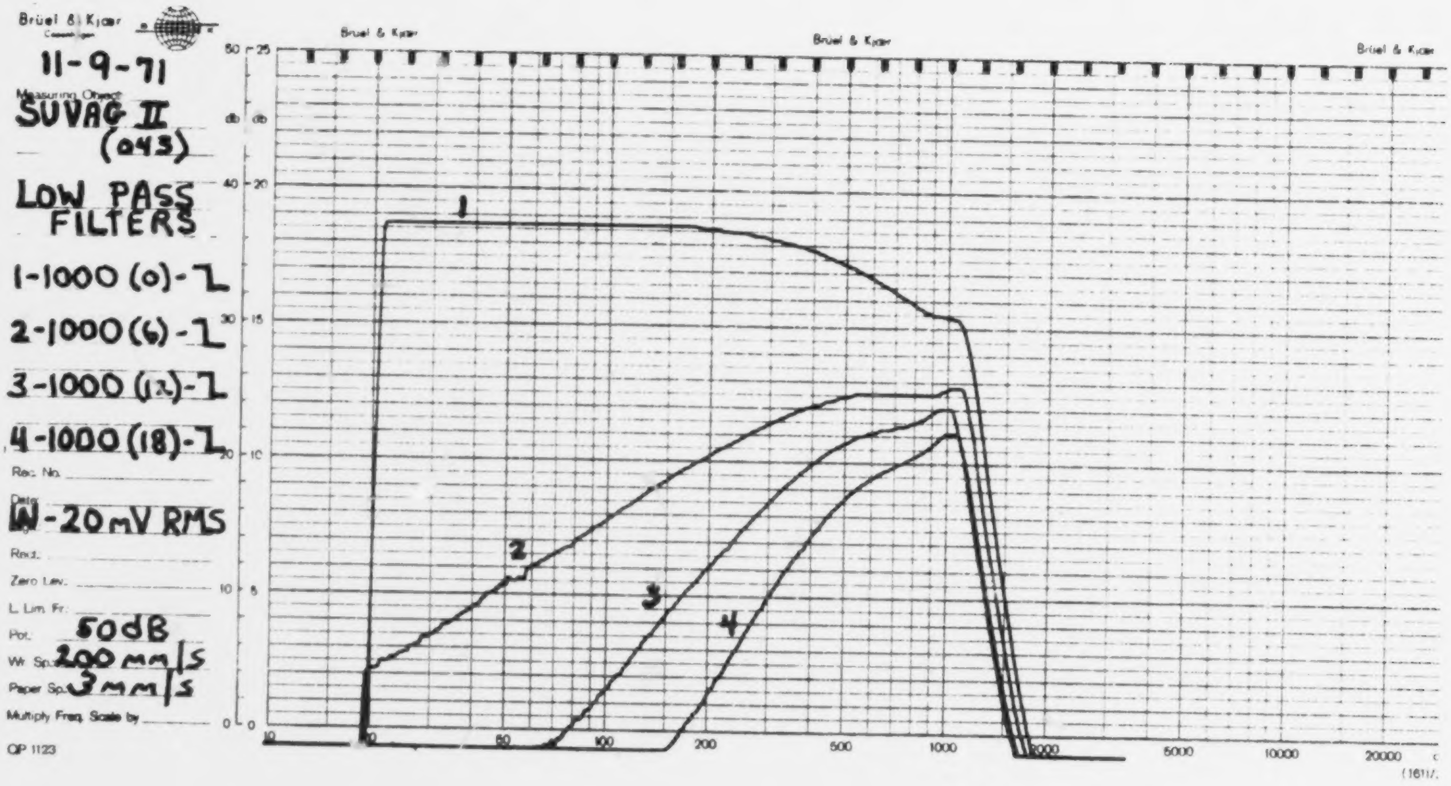


Figure 95 . Frequency Response of the Suvag II, Serial No. 043
(1000 Hz Low-Pass with 0, 6, 12, and 18 dB/Octave Roll-Off)

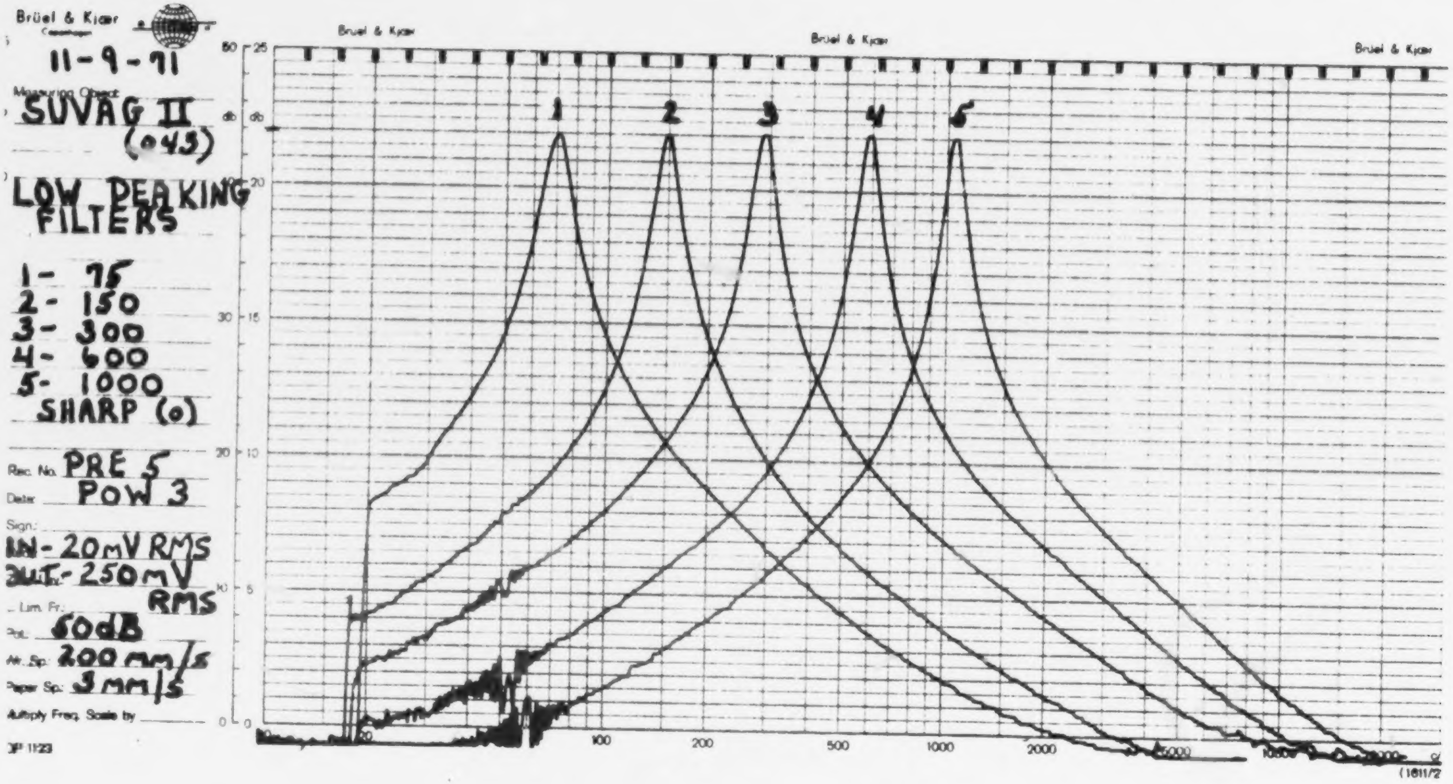


Figure 96. Frequency Response of the Suvag II, Serial No. 043 (Low-Peaking Filters of 75, 150, 300, 600 and 1000 Hz Set at Sharp Roll-Off)

A high-pass filter section is also provided. Its arrangement is similar to the low-pass section; its major filters are high-pass, but it also includes low-pass filters to provide an adjustable slope to the right of the break frequency. The set of resonant peaking filters is identical to the set of peaking filters in the low-pass section, but they are adjusted for a set of higher frequencies. The responses of each filter are presented in Figures 97 through 99 .

The particular unit shown in the block diagram (Figure 85) contains four level controls, one for each filter section, one for direct and one for an overall control. By adjusting these controls and selecting appropriate filter settings, a wide variety of frequency responses may be obtained. One of the possible combinations is displayed in Figure 100.

Rack Outputs for the Classrooms Using Suvag I and Warren T-2 Auditory Training Units

In appearance, the Suvag and Warren output racks are identical. The wiring of each rack, however, is unique for each unit in accordance with its particular output characteristics. The actual wiring diagrams for each unit may be seen in Figures 101 and 102 . A maximum output level of approximately 122 dB SPL at 1K Hz is set by adjusting the gain controls of each unit. However, a 3 dB SPL drop in output level occurs at any given earphone when all other output controls are changed from 0 to maximum. Table 26 displays the SPL output for each volume control setting.

TABLE 26

SOUND-PRESSURE OUTPUT FOR EARPHONES ACCORDING TO VOLUME SETTINGS ON THE RACKS

	Volume Setting	Output in dB SPL
Linear Steps	10 (max)	122
	9	120
	8	118
	7	116
	6	114
	5	112
	4	110
	3	108
	2	105
	1	99
	0	83

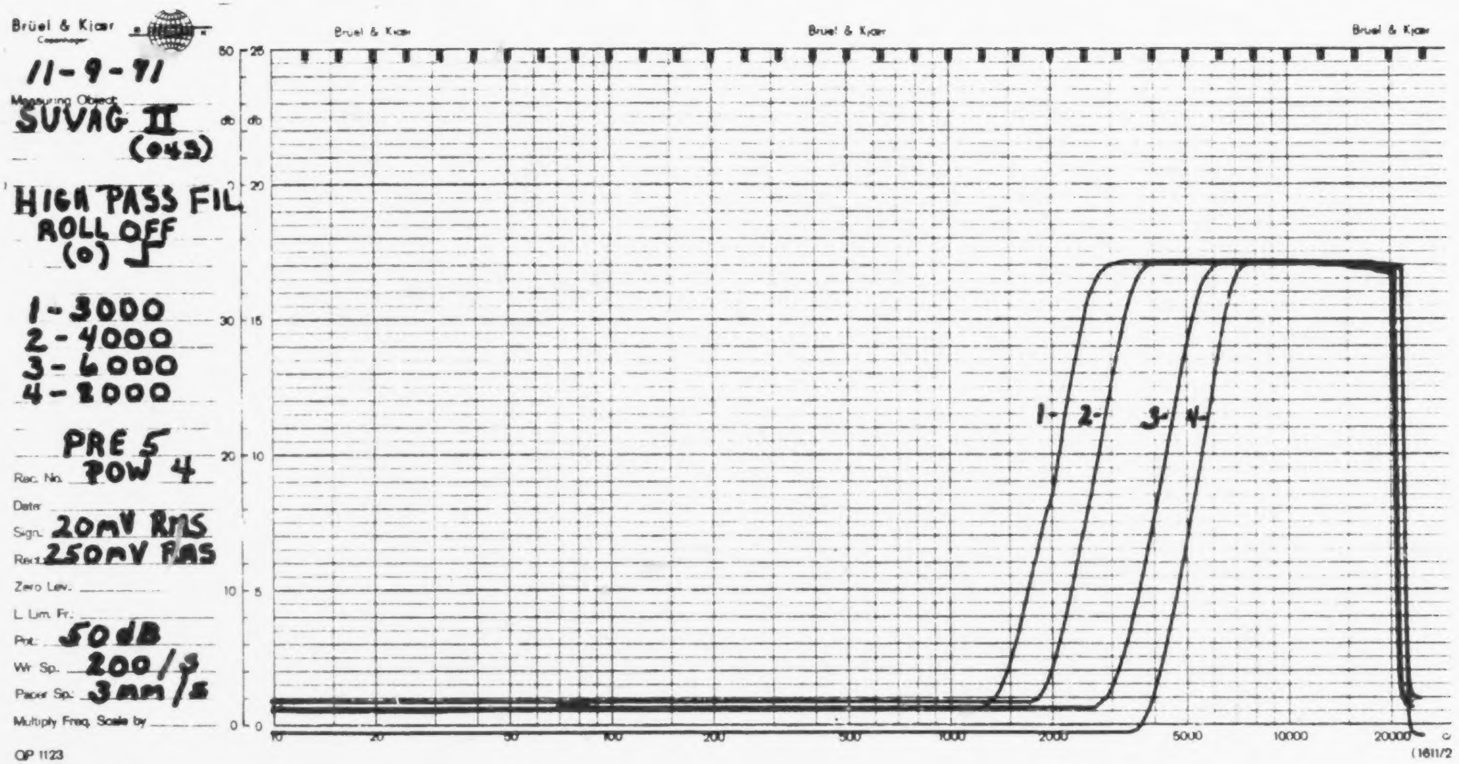


Figure 97 . Frequency Response of the Suvag II, Serial No. 043 (High-Pass 3000, 4000 and 6000 Hz.)

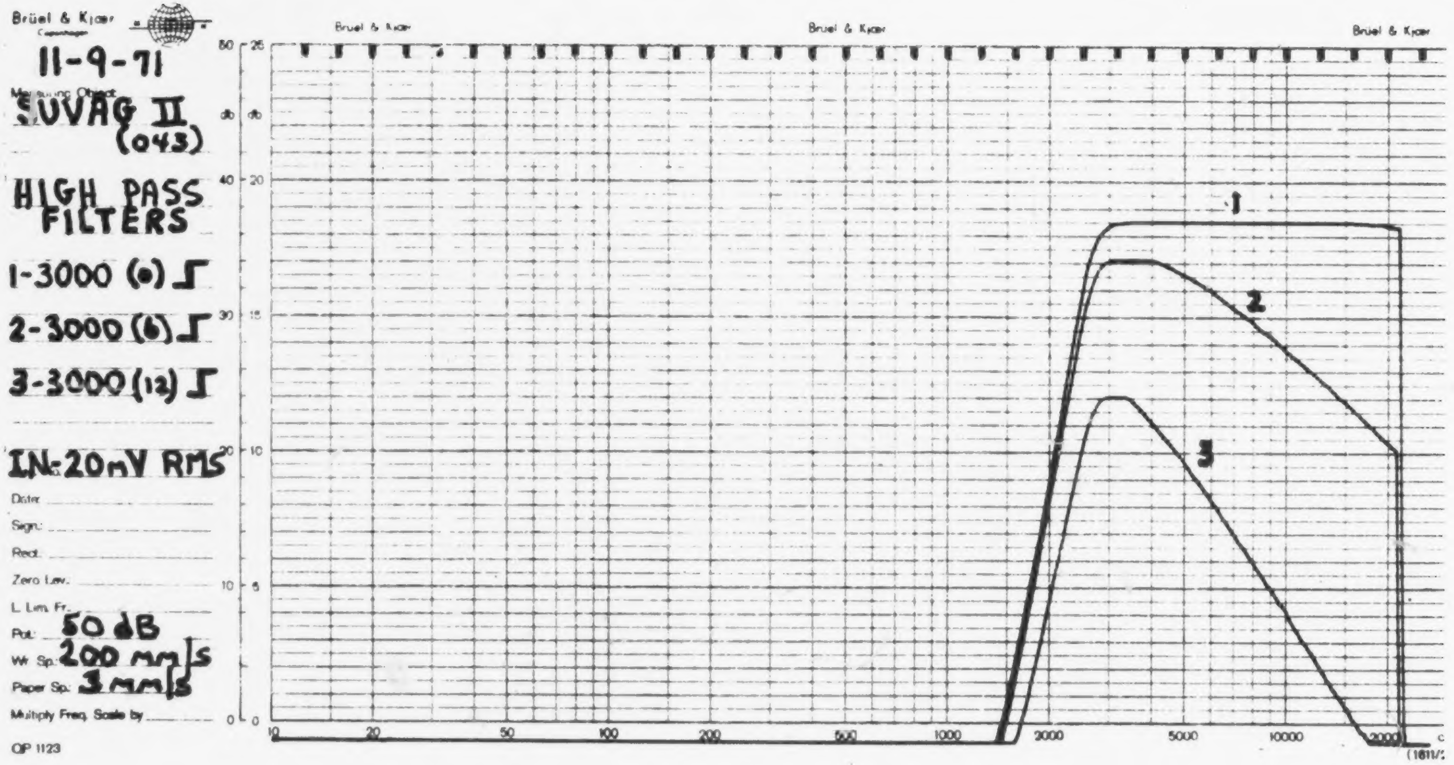


Figure 98 . Frequency Response of the Suvag II, Serial No. 043 (High-Pass 3000 Hz with 0, 6, and 12 dB/Octave Roll-Off)

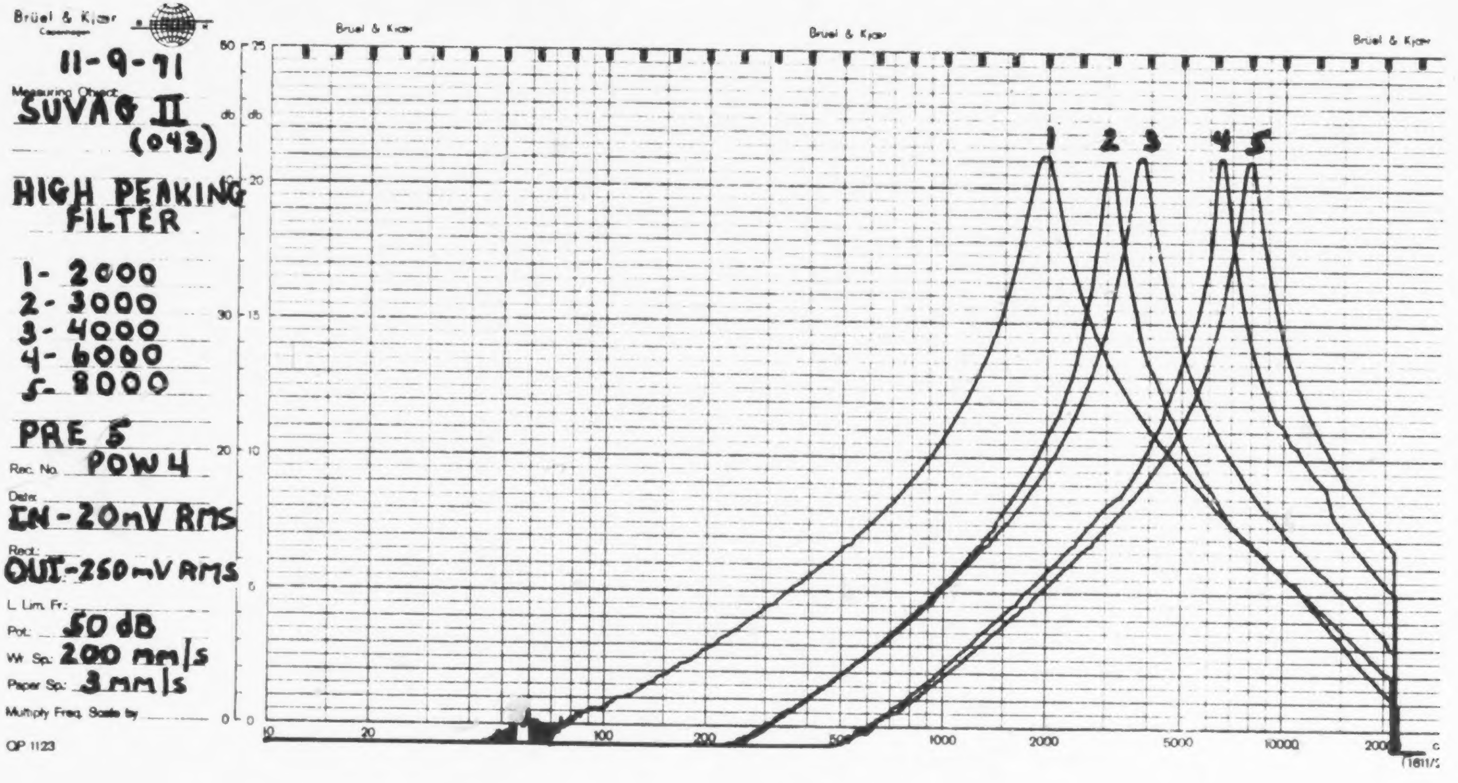


Figure 99 . Frequency Response of the Suvag II, Serial No. 043
(High-Peaking Filters of 2000, 3000, 4000, 6000, and 8000 Hz)

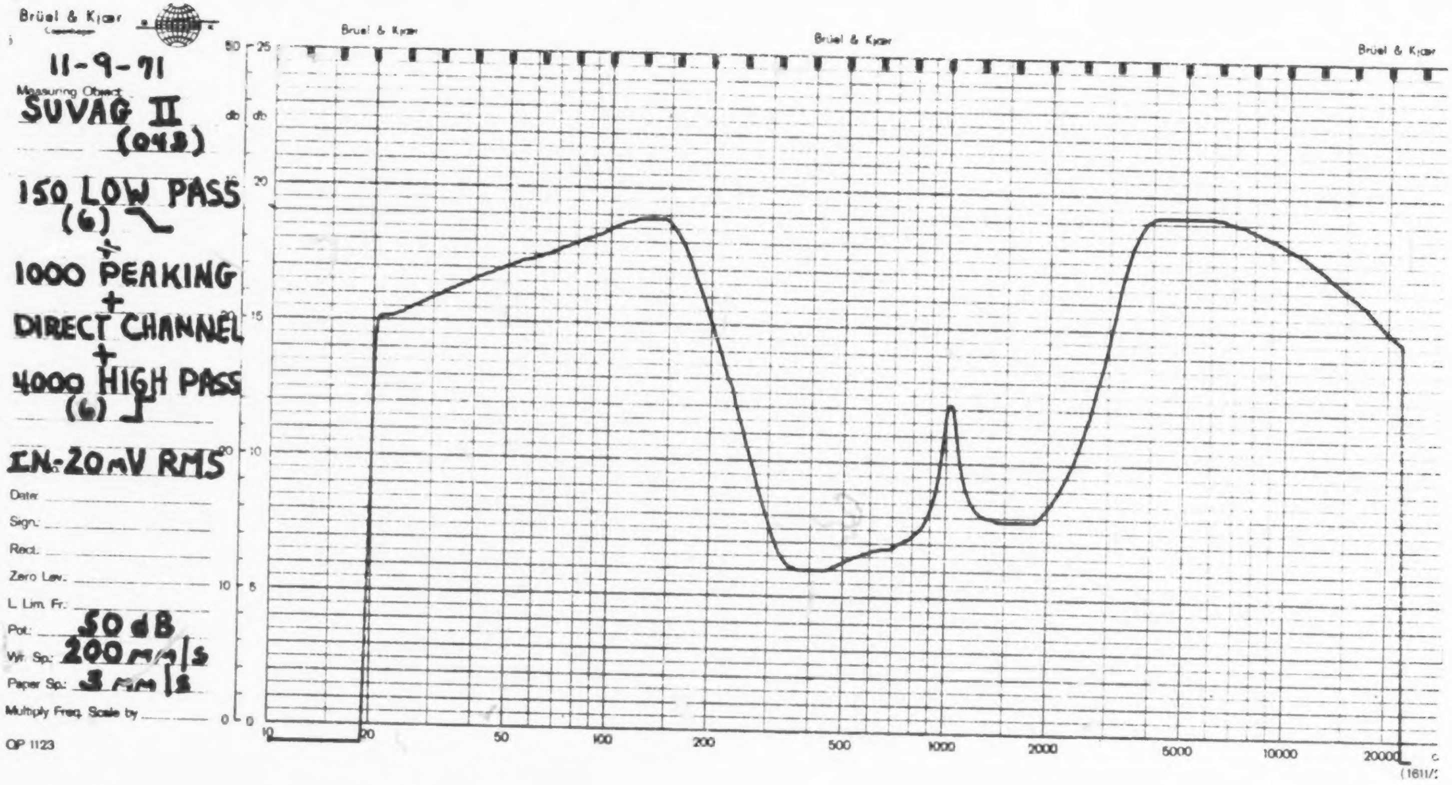


Figure 100. Frequency Response of the Suvag II, Serial No. 043 (Low-Pass (6) ¬ , Peaking 1000, Direct Channel, and High-Pass (6))

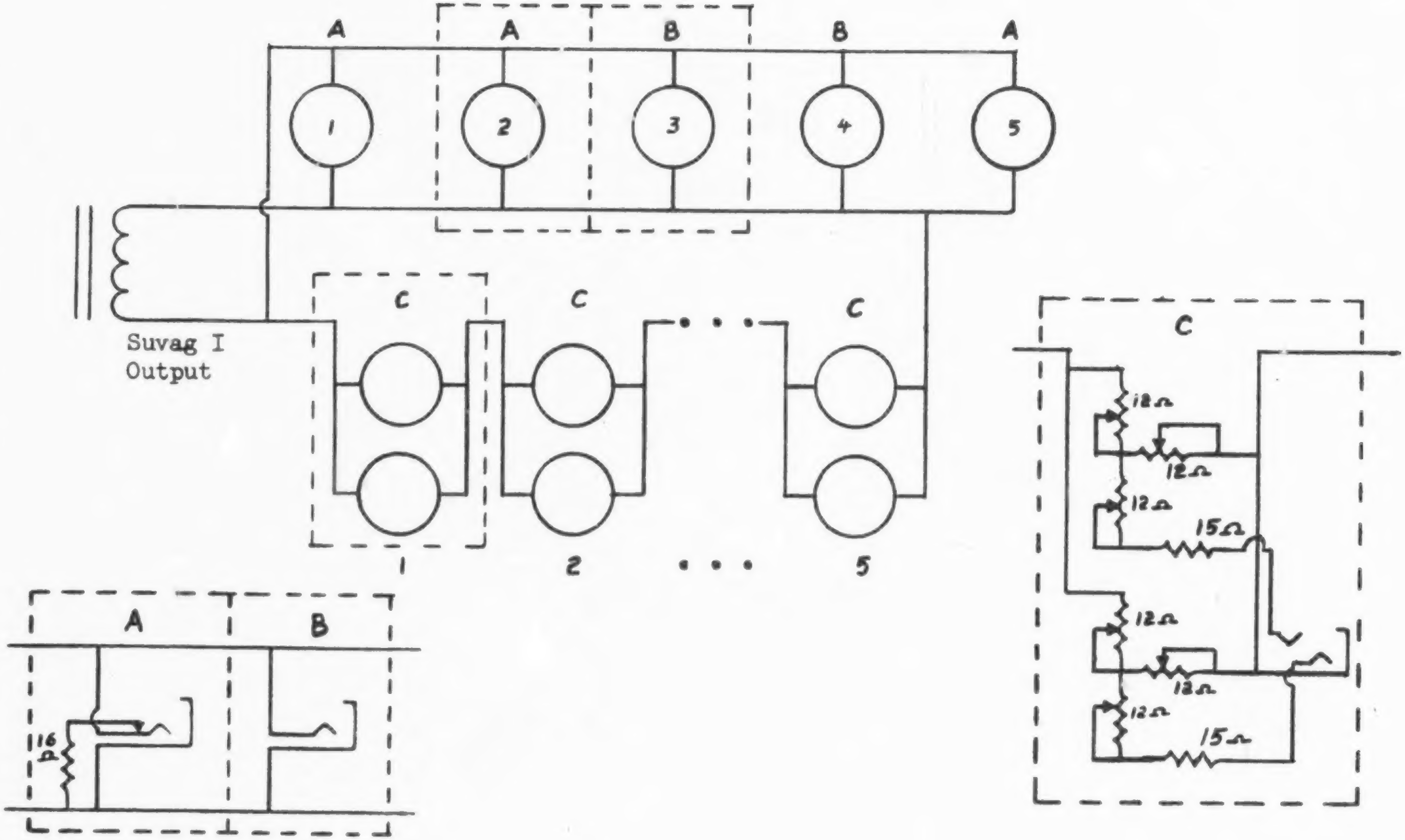

A
A
B
B
A
1
2
3
4
5
Suvag I Output
C
C
C
1
2
5
A
B
16 Ω
C
12Ω
12Ω
12Ω
15Ω
12Ω
12Ω
12Ω
15Ω

Figure 101 . Diagram of the Suvag I Rack Outputs.

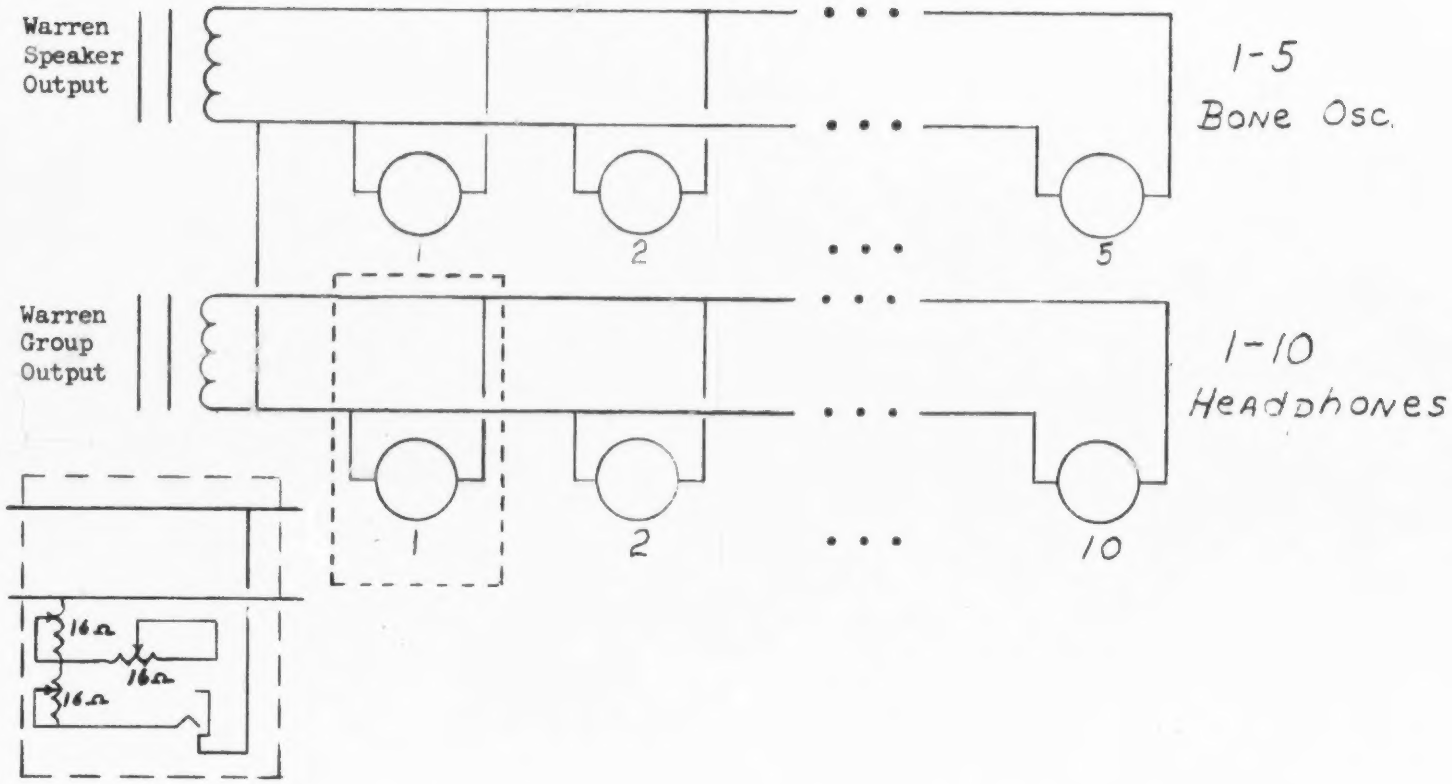

Warren
Speaker
Output
Warren
Group
Output
1-5
Bone Osc.
1-10
Headphones
1
2
5
1
2
10
16Ω
16Ω
16Ω

Figure 102 . Diagram of the Warren Rack Outputs.

Mini Suvag

The Mini Suvag is a body hearing aid that amplifies a wide range of frequencies. It utilizes a crystal microphone input, is constructed of potted circuit modules, and has two outputs. When accompanied by its rechargeable power amplifier, the Mini Suvag is an extremely versatile system.

A block diagram in Figure 103 demonstrates the location of the two outputs. The gain control which affects both outputs one and two is located on the top of the aid and is accessible from the exterior. Output two may be adjusted to a lower level than output one by adjusting the attenuator which is located inside the aid adjacent to the batteries. These outputs allow the user to choose any of the combinations shown in Figure 104. If one receiver is to be used, it may be connected to output one with a level that is controlled by the gain control or it may be connected to output two and the attenuator may be set to limit the SPL capability of the aid. The second arrangement is often used for young children if there is fear of further hearing loss due to over-stimulation. Bilateral stimulation may be achieved by using both output one and two with the level of output two being equal to or less than output one depending on the setting of the attenuator. A 100 ohm headset may also be used with the body aid.

The Mini Suvag power amplifier boosts the output of the body aid to a level which is sufficient to drive either the Suvag Vibar bone oscillator or a low-impedance headset. The amplifier is made up of potted circuit modules and is powered by rechargeable batteries. To provide both headset and bone oscillator outputs, one may connect a 100 ohm headset to output one of the body aid, the power amplifier to output two and a bone oscillator to the output of the power amplifier. This configuration will allow necessary level adjustment for either output transducer. This hearing aid can be utilized as an auditory training unit.

Maintenance of the Mini Suvag circuitry has not been a problem with the exception of the crystal microphone. It is damaged by heat and shock and is often in need of replacement, especially during the summer months. The replacement of these microphones has been very inexpensive.

The acoustical frequency response of the Mini Suvag obtained in the Suttle sound-treated booth, may be seen in Figure 105 , while Figure 8 shows the acoustical frequency response obtained in the Brüel and Kjaer hearing aid test box. The following are the specifications of the Mini Suvag measured in the test box according to HAIC standards: average gain - 52 dB, maximum power output - 125 dB, frequency range - 20 Hz or less to 4000 Hz.

Zenith Vocalizer II

The Zenith Vocalizer II is a durable "wide" frequency response body type hearing aid. It is equipped with two input transducers, a microphone, and a telephone pick-up. The frequency response of the aid, obtained in the Suttle sound-treated booth, may be seen in Figure 106 , and should be compared with the response of the Mini Suvag seen in Figure 105 . The frequency response in Figure 9 was obtained in the Brüel and Kjaer hearing aid test box. The following are the specifications of the Zenith Vocalizer II as measured in the test box according

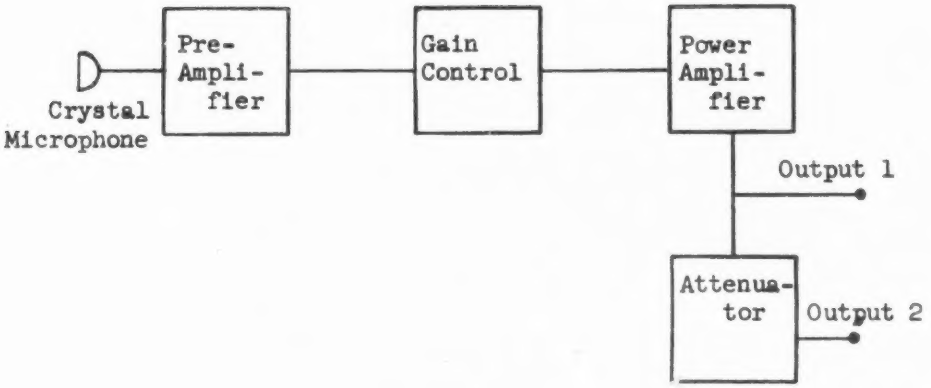

Crystal Microphone
Pre-Amplifier
Gain Control
Power Amplifier
Output 1
Attenuator
Output 2

Figure 103. Block Diagram of the Mini Suvag.

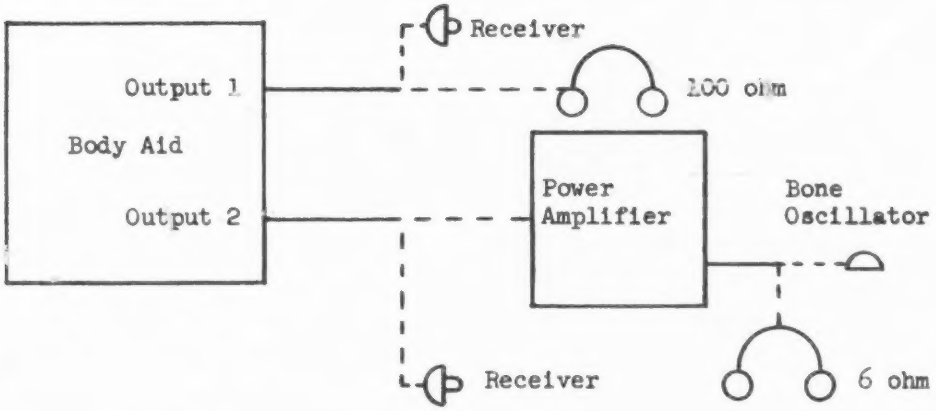
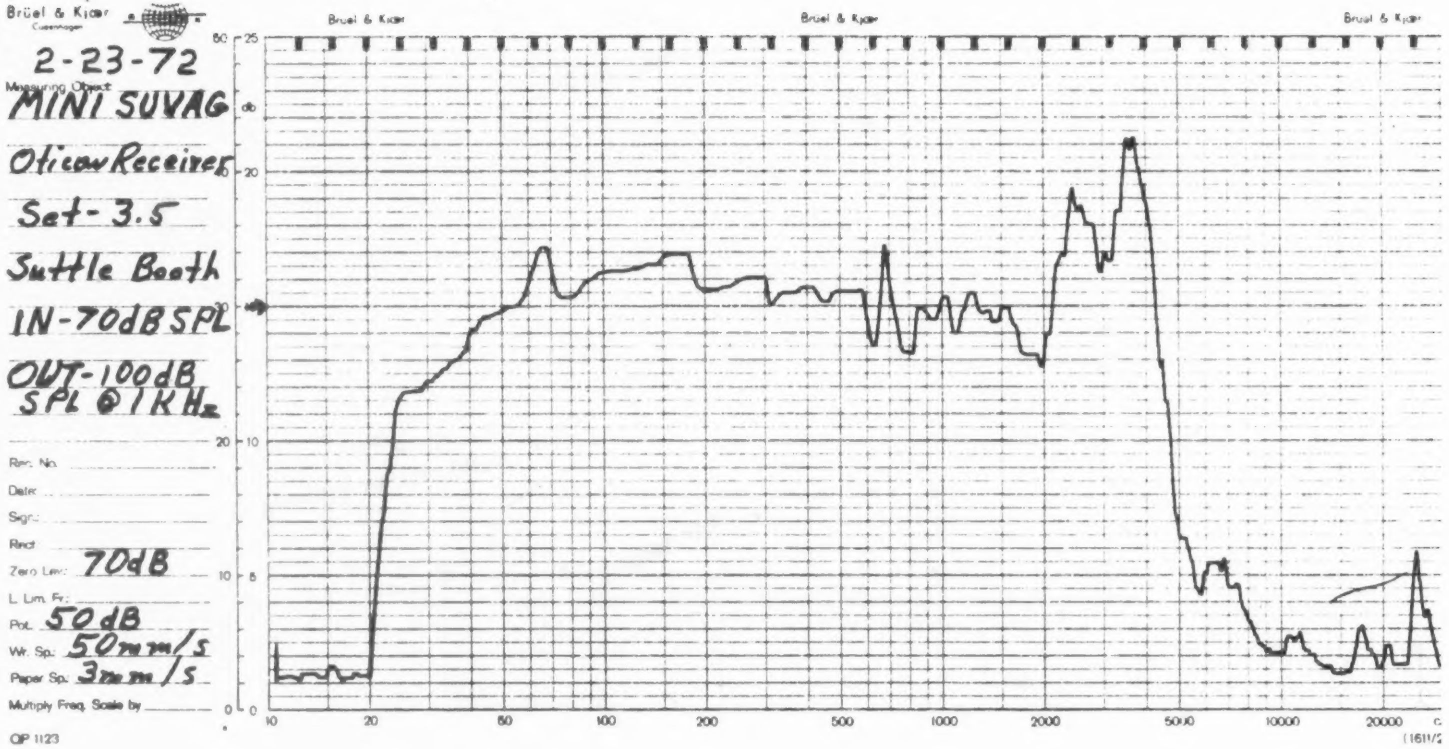

Receiver
Output 1
100 ohm
Body Aid
Power Amplifier
Bone Oscillator
Output 2
Receiver
6 ohm

Figure 104. Block Diagram of the Possible Connections for the Mini Suvag.



2-23-72

Measuring Object MINI SUVAG

Oticon Receiver

Set- 3.5

Suttle Booth

IN-70dB SPL

OUT-100dB SPL @ 1KHz

Rec. No.

Date:

Sign.:

Rect.

Zero Lev.: 70dB

L. Lim. Fr.:

Pot. 50dB

Wr. Sp. 50mm/s

Paper Sp. 3mm/s

Multiply Freq. Scale by

Figure 105. Frequency Response of the Mini Suvag
(acoustical input and acoustical output)

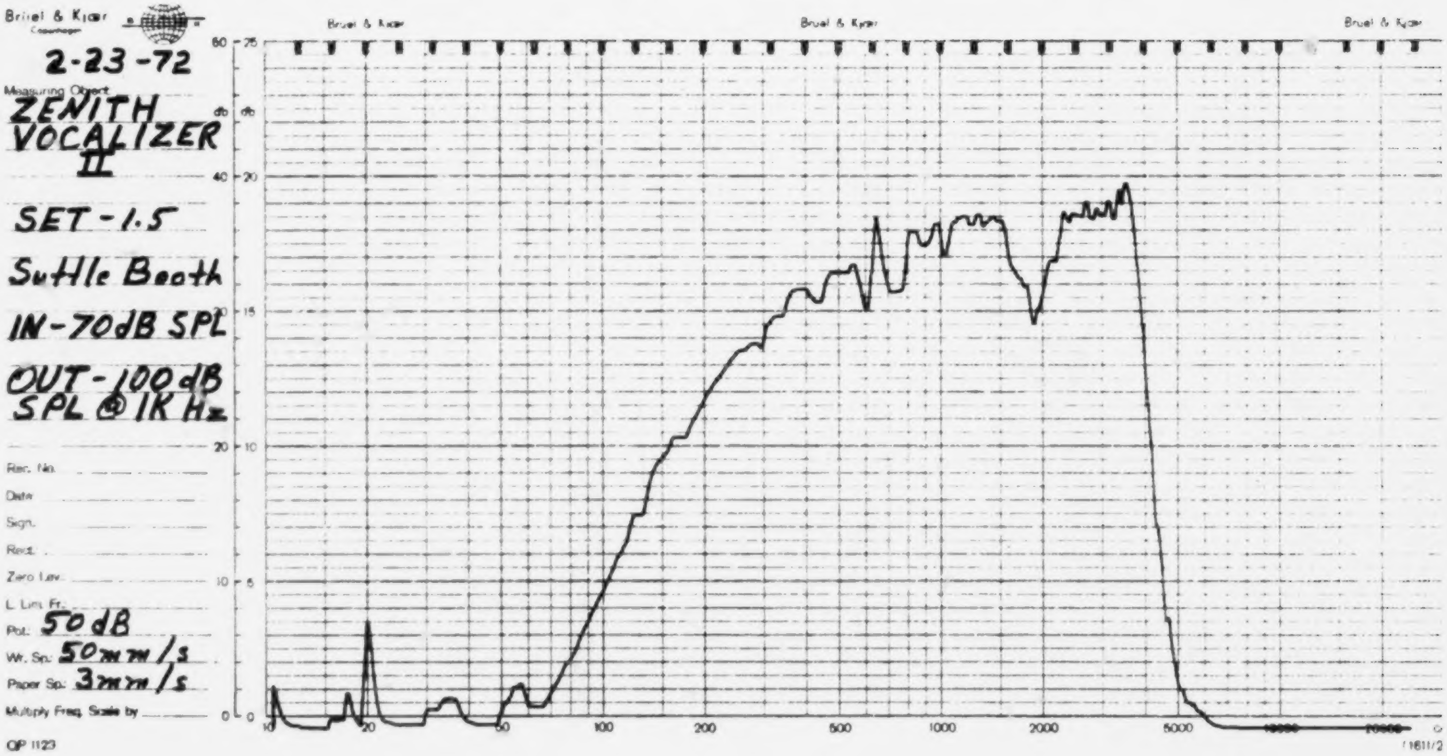


Figure 106. Frequency Response of the Zenith Vocalizer II
(acoustical input and acoustical output)

to HAIC standards: average gain - 63 dB, maximum power output - 132 dB, frequency range - 200 Hz to 3500 Hz.

CHAPTER IX
ELECTRONIC INSTRUMENTATION DESIGN FOR QUANTIFICATION

James W. Keller, B.S.,
Philip Williams and Carl Sellers

An important phase of this research project is to determine a subject's progress and to better understand the factors which affect this progress. Specific parameters which may indicate a subject's ability to verbally communicate must be identified and measured as accurately as possible. An attempt must also be made to quantify speech parameters. The measurement of these parameters is directly related to the design of the instruments involved. Consequently, a precise measurement may only be obtained when instrument characteristics are fully understood and carefully controlled.

Whenever possible commercially available equipment is purchased to take these measurements. In many cases an alteration or new design is required as more is learned about a particular parameter under measure. This chapter will describe the status of existing instruments being used for our quantification measures.

Verbo-Tonal Audiometer

This is a totally-conventional unit which includes a tone generator, a tape recorder, a variable attenuator, and a noise generator (with a separate variable attenuator). See the block diagram in Figure 107. TDH-39 earphones with 41MX-AR cushions are used. See audiometry section of this report for calibration procedures.

Vocalizations

Vocalizations were measured by the Grason-Stadler Voice Operated Relay (VOR), in early studies of vocalization rates. Because of the variable attack and release time on the relay output, this instrument is not capable of accurately measuring the duration of a vocalization. As seen in Figure 108, the attack and release time is dependent upon the previous input sequence. A new instrument was needed which would be capable of providing a more accurate duration measure of each vocalization.

The vocalization instrument which is currently being used in the program to measure both the rate and duration of vocalizations is displayed in Figures 109 and 110. A definition of a vocalization is most precisely given by explaining the operation of this circuit, but in general terms it is defined as the phenomenon occurring when the voice is producting an acoustical output. The instrument first amplifies the audio signal and produces a pulse each time the waveform reaches a relatively low trigger level. These pulses then activate a circuit which produces a sustained output for a predetermined interval after the input pulses have ceased. The length of this output is then timed and counted as one vocalization.

More precisely, the trigger section of the circuit produces a pulse which is always shorter than the period of the highest human fundamental frequency (less than 0.1 millisecond). More than one pulse is produced for each cycle of the vocal folds since no effort is made to filter out harmonics. The level required to produce a pulse is governed by the first transistor which will conduct when its base voltage exceeds the base-to-emitter drop of 0.6 volt. A VU meter is provided so that the relative level of the amplified input signal may be compared to the known trigger level of 0.6 volt.

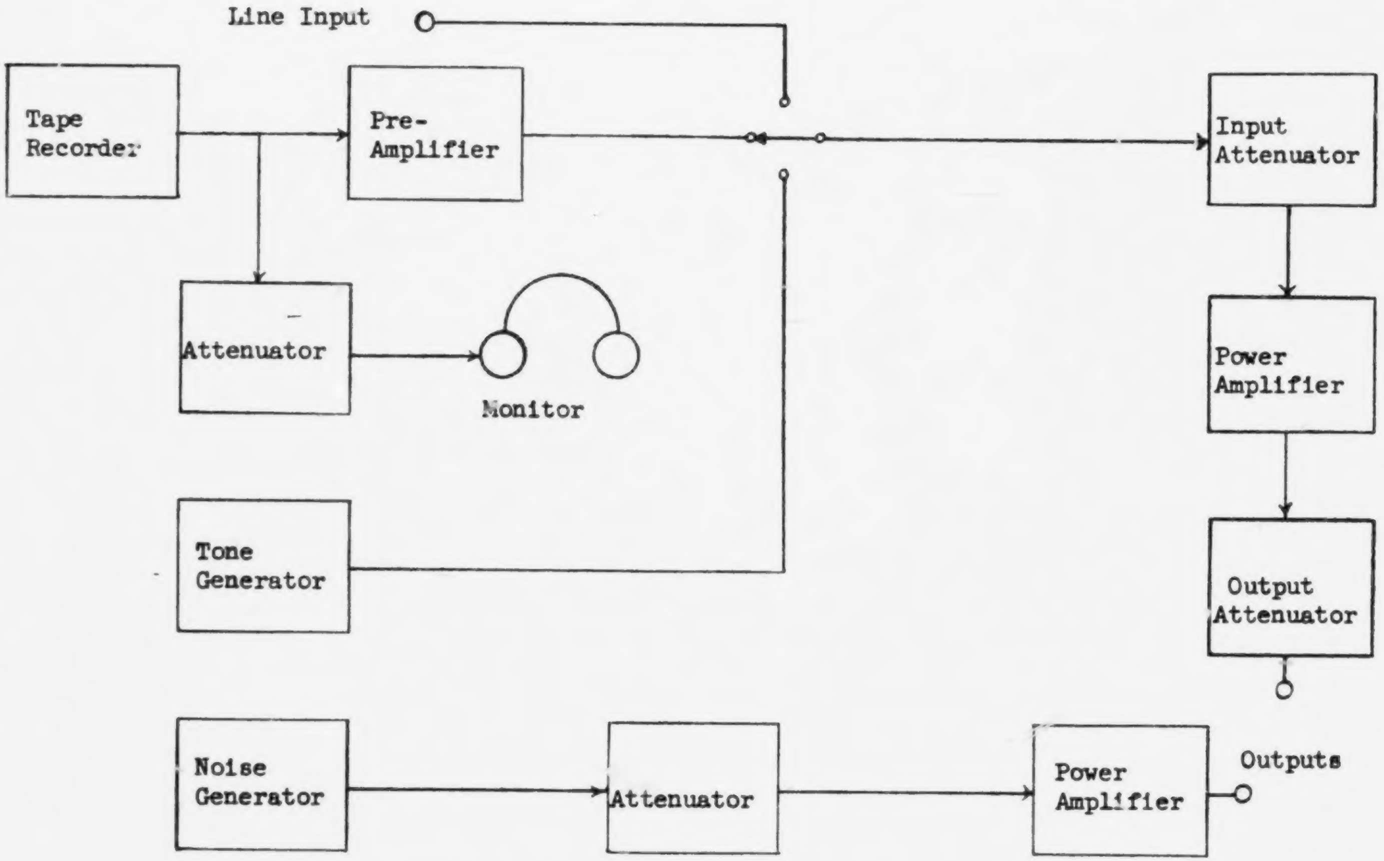
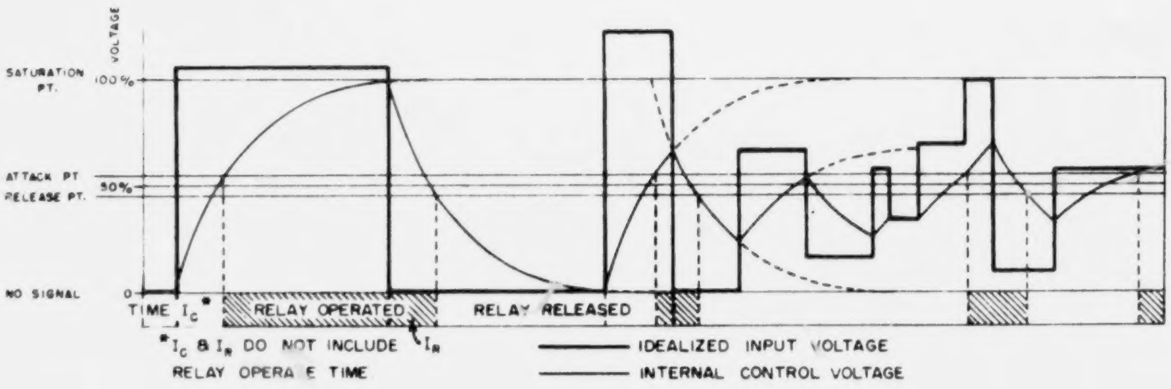
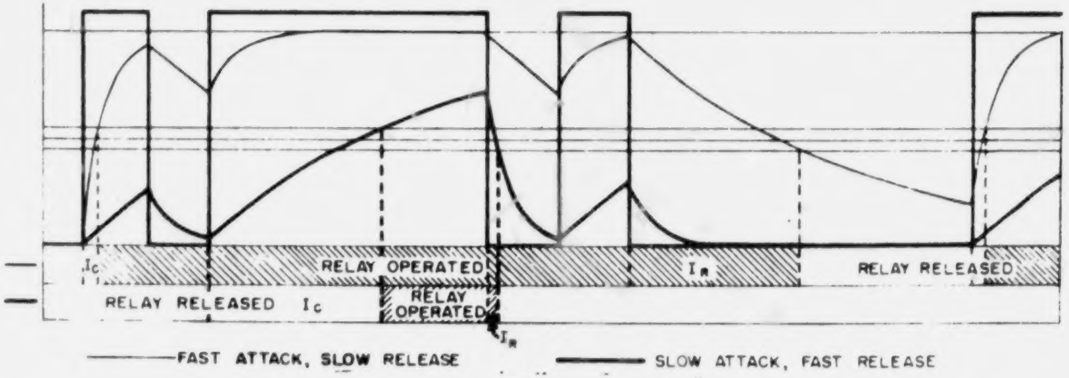

Line Input
Tape Recorder
Pre-Amplifier
Input Attenuator
Attenuator
Monitor
Power Amplifier
Tone Generator
Output Attenuator
Noise Generator
Attenuator
Power Amplifier
Outputs

Figure 107 . Block Diagram of the Verbo-tonal Audiometer.



EQUAL ATTACK AND RELEASE SETTINGS



UNEQUAL ATTACK AND RELEASE SETTINGS

Figure 108. Description of the Attack and Release Time of the VOR.

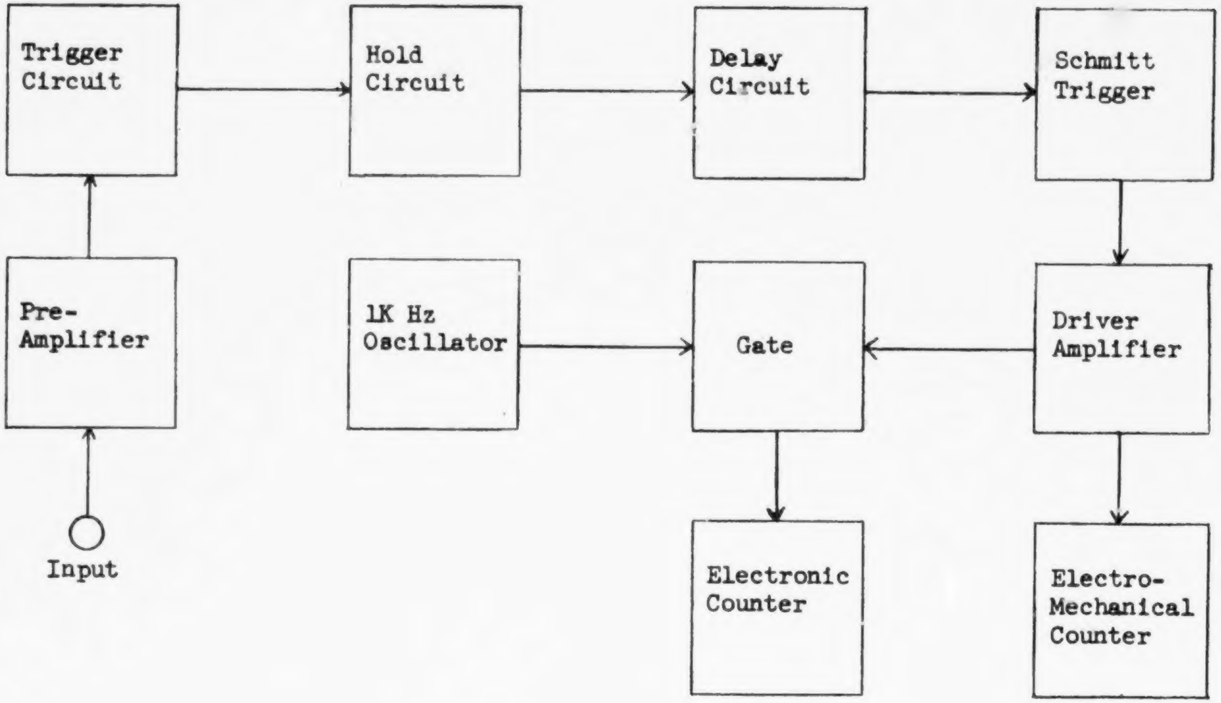

Trigger Circuit
Hold Circuit
Delay Circuit
Schmitt Trigger
Pre-Amplifier
1K Hz Oscillator
Gate
Driver Amplifier
Input
Electronic Counter
Electro-Mechanical Counter

Figure 109. Block Diagram of the Vocalization Circuit.

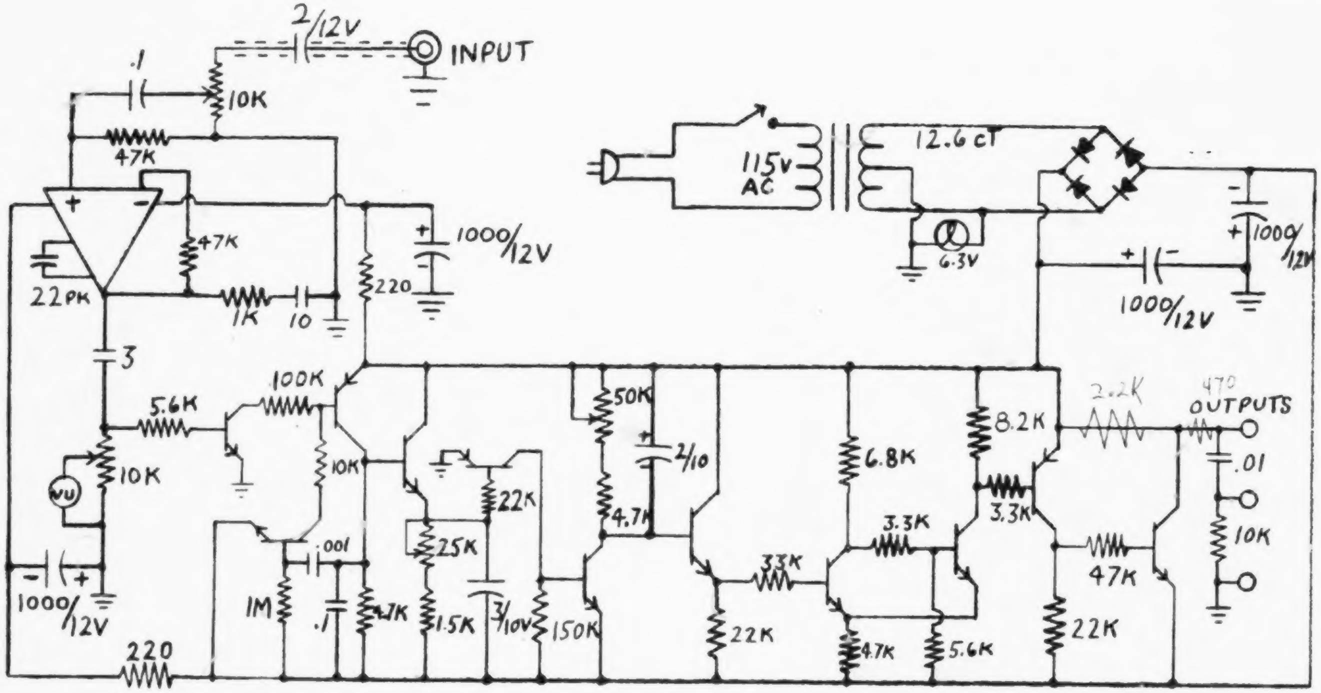

2/12V
INPUT
.1
10K
47K
47K
22PK
1K
10
220
1000/12V
3
5.6K
100K
10K
10K
WU
1000/12V
220
1M
.001
.1
4.7K
22K
25K
1.5K
3/10V
150K
50K
4.7K
2/10
22K
33K
6.8K
3.3K
4.7K
5.6K
8.2K
3.3K
47K
22K
2.2K
470
OUTPUTS
.01
10K
115V AC
12.6 CT
6.3V
1000/12V
1000/12V

Figure 110. Circuit Diagram of the Vocalization Circuit.

These pulses, which represent the existence of an input signal, are then used to trigger the hold circuit, which produces a level output which remains on between pulses for the duration of one vocalization. The length of time after an input pulse, to cause a drop in the output of the hold circuit, is variable; however, a duration of 20 milliseconds has been found to be most desirable. This time (20 milliseconds) is long enough to hold the output on for an input signal which contains as low a fundamental frequency as 50 Hz without counting the individual wave forms. The circuit is, however, allowed to release if a pause between vocalizations is greater than 20 milliseconds.

The delay circuit will produce an output only if the output from the hold circuit is of greater duration than a preset value. A delay of 40 milliseconds is used for our measurements. The sole purpose of this circuit is to eliminate short duration noise of sufficient intensity to fire the trigger circuit. A setting of 40 milliseconds does, however, discount any vocalization which is less than 40 milliseconds in duration. But vocalizations of this short a duration are unlikely to occur, and the noise rejection properties have been found to be most helpful.

Both the hold circuit and the delay timing circuits have been designed in order to accurately repeat a preset timing interval, regardless of the previous input sequence. That is, if the circuit receives a new input pulse before the preceeding timing sequence has been completed, a new sequence will be initiated.

The state of the delay circuit is then sensed by the Schmitt trigger, and an output pulse corresponding to a vocalization results. To provide a rate count, an electromechanical counter containing a trigger amplifier (See Figure 111) is connected to the output. A duration measure is obtained by using the output to gate a 1 KHz tone into an electronic counter. This tone is obtained from the 1 MHz crystal oscillator located in the electronic frequency counter (Heathkit, model IB-101) which has been modified to accumulate input pulses. A correction factor of plus 20 milliseconds must be added to the duration of each vocalization because of the 40 millisecond delay and the 20 millisecond hold circuit.

Fundamental Frequency

Fundamental Frequency is measured by the Trans Pitchmeter. The principle of its operation may be best described by an explanation of the block diagram in Figure 112 . The section of the instrument which provides a level indication is not utilized and shall not be discussed. When a voice input is used and appropriate adjustments are made, the level of a sawtooth output will indicate the fundamental frequency of the voice.

As seen in the block diagram, the speech signal is filtered by the lowpass filter, which reduces the harmonics, and then by the high pass filter which reduces low frequency noise such as 60 Hz interference. The signal is then center clipped, amplified, and again center clipped. Center clipping makes it possible to obtain an output which represents the fundamental frequency without actually eliminating all of the harmonic components of the original speech waveform. An indication of the nature of the fundamental frequency is achieved by displaying the duration of the period of each cycle of the signal. This provides a continuous readout which represents an accurate measure of the intonation. The actual procedure to obtain this output is to integrate a level which is uniform in

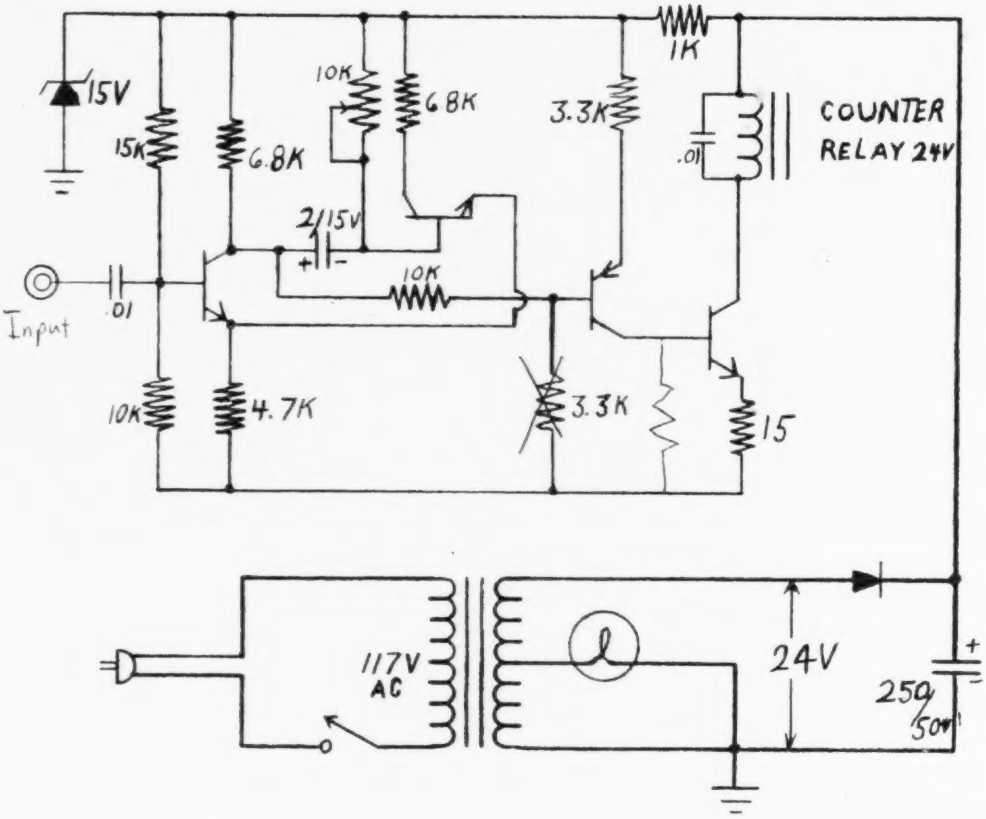

15V
15K
6.8K
10K
6.8K
3.3K
1K
.01
COUNTER
RELAY 24V
2/15V
+
-
10K
Input
.01
10K
4.7K
3.3K
15
117V
AC
24V
+
250/50V

Figure 111. Circuit Diagram of the Triggering Circuit for the Electro-Mechanical Counter.

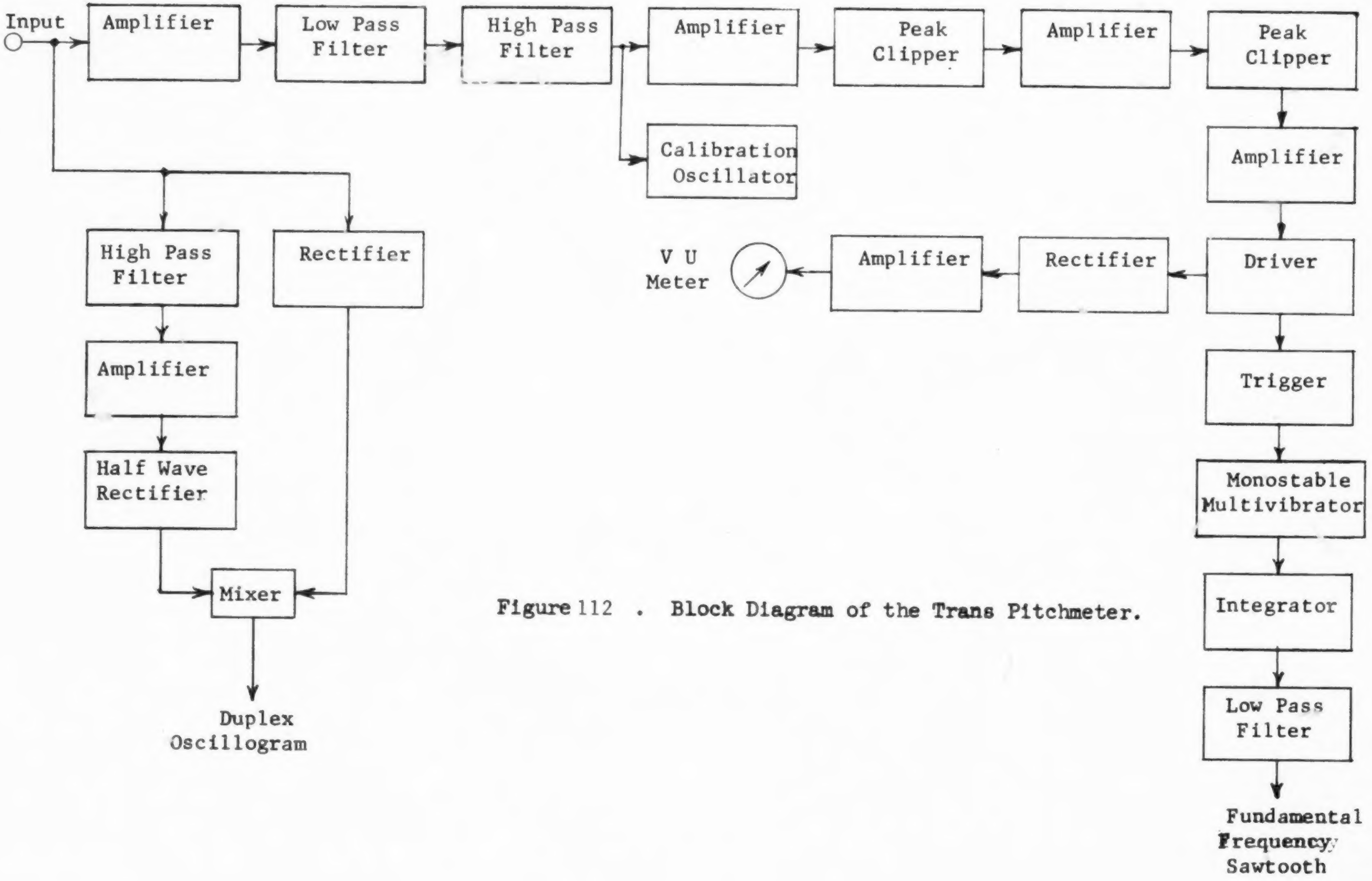

Input
Amplifier
Low Pass Filter
High Pass Filter
Amplifier
Peak Clipper
Amplifier
Peak Clipper
Calibration Oscillator
Amplifier
Driver
Rectifier
Amplifier
V U Meter
Trigger
Monostable Multivibrator
Integrator
Low Pass Filter
Fundamental Frequency Sawtooth
High Pass Filter
Rectifier
Amplifier
Half Wave Rectifier
Mixer
Duplex Oscillogram

Figure 112 . Block Diagram of the Trans Pitchmeter.

magnitude and corresponds in length to the period. Thus the amplitudes of the resulting sawtooth peaks correspond to the period of the fundamental. A low pass filter helps to reduce the peak-to-peak amplitude of the sawtooth but maintains the level which indicates the value of the frequency.

The only desired output of this circuit is the value of the fundamental frequency versus time. This is a line which must rapidly change from 0 Hz to the value of the fundamental, fluctuate gradually, and then return abruptly to 0 Hz at the end of the vocalization. The actual output, however, contains remains of the sawtooth waveform which contain much higher frequency components than the contour of the intonation. For this reason the only means of display is a high frequency level recorder or a storage oscilloscope. We currently are using the storage oscilloscope.

A method which we are currently testing involves an output which contains a level corresponding only to the length of each period. This type of display does not contain the sawtooth waveform and therefore can be recorded on a low frequency (DC-100 Hz) level recorder which is considerably less expensive than the high frequency (DC-7 KHz) level recorder required for the Trans Pitchmeter. Further information on this new output technique will appear in later reports.

Mechanization of the Preparation of Recorded Samples

The 1-9 score evaluation does not require measurements in the actual judgement of samples; however, methods of sample preparation have been mechanized. The time-consuming process of randomizing samples for the 1-9 evaluation is now expedited by the use of the Teac model TCA-40 4-channel playback deck, Teac model TCA-42 4-channel record/playback deck, and the custom switching circuit seen in Figure 113. It is necessary to mix the samples in such a way so as not to bias the judgements of the listeners. Each step in the preparation of the list of samples is orderly and the final location of each sample is accurately predicted by a computer.

Editing the original recorded samples is facilitated by altering the circuitry of the tape recorders and also by automatically locating the desired sample on the tape. The circuit alteration allows the operator to switch between the forward and reverse playback modes without automatically switching channels. Thus the operator may "rock" the tape back and forth to cue up the desired sample. The sample is then recorded on a second recorder in an automatically-chosen location. This location is selected by an activation of the automatic stop of the recorder by a sensing of a pre-recorded tone. This is accomplished by a switching circuit seen in Figure 113.

The switching matrix seen in the block diagram of Figure 114 is then used to rearrange the location of the samples across channels. This totally-automatic process switches the outputs of the playback recorder to different input locations on the second recording unit each time a new sample is indicated by the pre-recorded tone. Groups of 100 samples are presented to judges and the judges' scores are then entered into the computer by optical scan sheets.

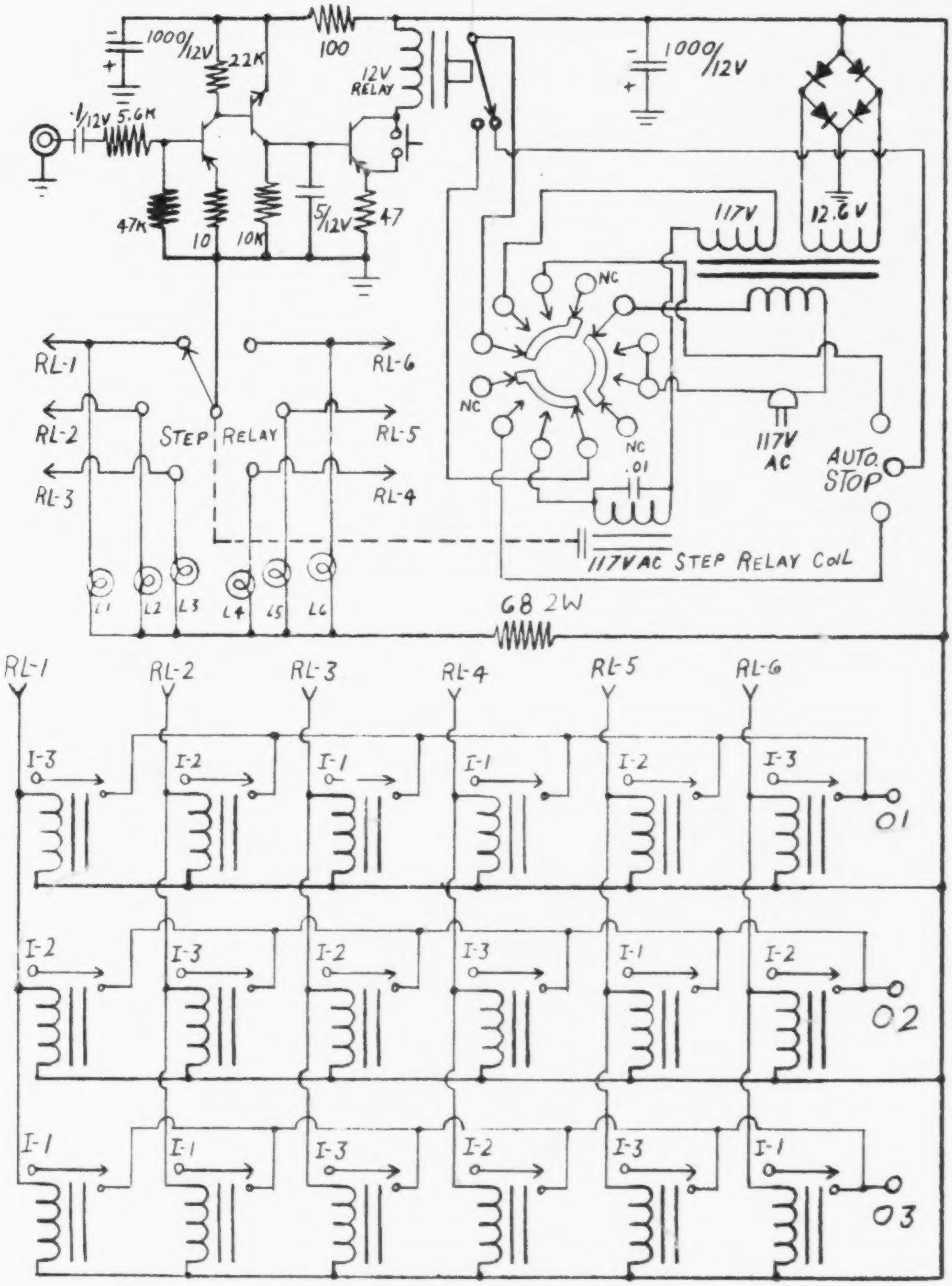
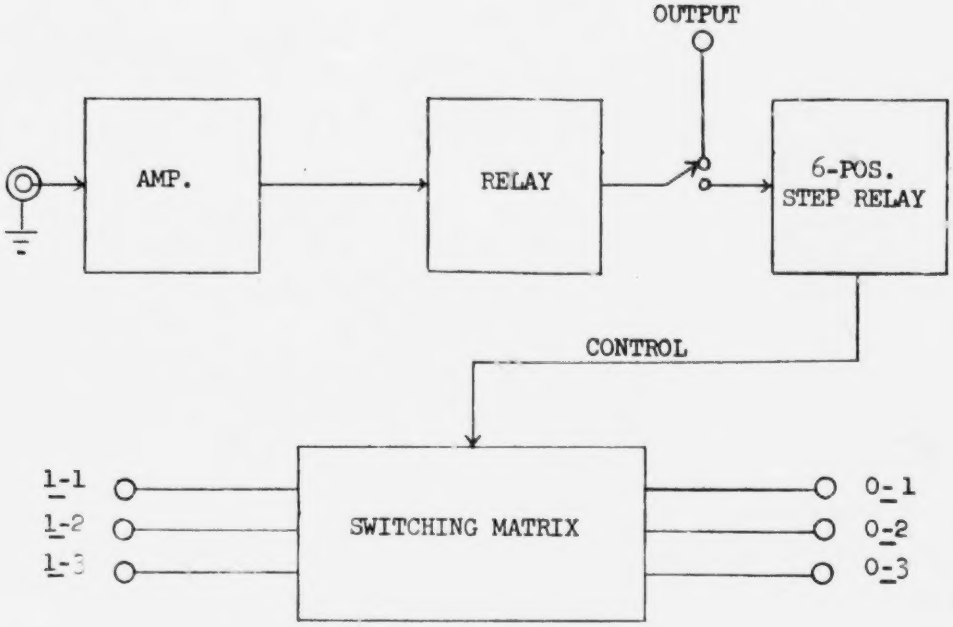

1000/12V
22K
100
12V RELAY
1000/12V
.1/12V
5.6M
47K
10
10K
5/12V
47
117V
12.6V
NC
NC
NC
RL-1
RL-2
RL-3
RL-6
RL-5
RL-4
STEP RELAY
117V AC
.01
AUTO. STOP
117VAC STEP RELAY COIL
L1
L2
L3
L4
L5
L6
68 2W
RL-1
RL-2
RL-3
RL-4
RL-5
RL-6
I-3
I-2
I-1
I-1
I-2
I-3
O1
I-2
I-3
I-2
I-3
I-1
I-2
O2
I-1
I-1
I-3
I-2
I-3
I-1
O3

Figure 113 . Circuit Diagram of the Switching Circuit and Automatic Stop.


OUTPUT
AMP.
RELAY
6-POS.
STEP RELAY
CONTROL
1-1
1-2
1-3
SWITCHING MATRIX
0-1
0-2
0-3

STEPPING SEQUENCE	1-1	1-2	1-3
1	0-3	0-1	0-2
2	0-2	0-3	0-1
3	0-1	0-2	0-3
4	0-1	0-3	0-2
5	0-2	0-1	0-3
6	0-3	0-2	0-1

Figure 114 . Block Diagram of the Switching Circuit and Switching Sequence.

Filtered Speech

Laboratory equipment is being used to help quantify speech perception. Increased experience with filtered speech is leading to more elaborate instrumentation which may help isolate several factors in perception. Two instrument set-ups which are being investigated will be briefly discussed in the following paragraphs.

The most effective method found for filtering speech incorporates linear amplification and passive filtering. An Electro-Voice model RE 20 studio microphone, located in a Suttle sound-treated booth, transduced the acoustical signal which was amplified by a Shure model M67 microphone mixer. Two Allison model 2ABR passive filters, connected in series, filtered the signal. The amplitude of the signal was then adjusted by a Hewlett-Packard model 350C step attenuator and a custom amplifier. A third Allison filter was added to further reduce the signal level outside the pass band and also to reduce any noise added by the amplifier. The resulting signal was both presented to listeners and recorded on an Ampex model AG-440 tape recorder.

Preliminary results of studies utilizing this instrumental design indicate that level, duration, intensity fluctuations, bandwidth, and location of the band on the "frequency spectrum", are important factors in subjective discrimination between speech sounds. In an effort to narrow the width of the pass band, a Brüel and Kjaer type 2107 frequency analyzer was placed between the two Allison filters. The first filter reduced energy outside the pass band which would otherwise cause distortion in the amplifier of the frequency analyzer. The second filter helped remove amplifier noise.

Another arrangement allowed the operator to choose the portion of the speech sample to be presented. This was achieved by activating a Grason-Stadler model E 7300 A-1 voice-operated relay at the onset of the sample. A Grason-Stadler model 829E electronic switch passed a section of the sample for a desired duration with a specific rise and decay. Control of the electronic switch was accomplished through the use of Tektronix type 161 pulse generators and type 162 waveform generators.

CHAPTER X

RELATED RESEARCH: CONVENTION PAPERS AND THESES

This research project has been undertaken with specific aims that will be completed and reported. Because the project is conducted at a university, it is possible to stimulate and conduct additional research that evaluate some of the basic assumptions of the Verbo-tonal System.

One such area of research has been the twelve Masters theses by our graduate students that have been completed or are in progress. The authors of the completed theses are as follows: Marcia Bradberry, Connie Lawrence, Elizabeth McKenney, Todd Porter, Mary Peterson, Janis Shirley, and Linda Woodfin. Four of these theses will be or have been presented as convention papers at state and/or national conventions. These convention papers and also abstracts of completed theses have been included in this Chapter. The thesis by Janis Shirley may be viewed in Chapter XII on the Integration Program.

Five theses are still in progress. The thesis by John Berry may be viewed in Chapter IV on the Rate and Duration of Vocalizations. Patricia Parlato's thesis may be viewed in Chapter XI on the Reading Program. Three additional theses are in the planning stage. Two of these theses are investigating optimal octaves which is a basic concept in the Verbo-tonal System. One theses is attempting to develop a profile to determine the prognosis of preschool deaf children to learn from auditory training.

Local funds have been obtained from The University of Tennessee to conduct some additional research projects. These studies resulted in the convention papers by Asp and Lawrence, and the paper by Asp, Wood, and Keller.

A total of seventeen convention papers have been presented within the last three years that are related to this project. These papers are listed in the reference section at the end of this report.

As a vehicle for dissemination, a 4-hour short course in The Verbotonal System was presented by the writer at the American Speech and Hearing Convention, November, 1971. An outline of the short course is included in this chapter. As part of this course a 28-minute video tape was assembled and presented. The audio script of the video tape and also a 5-minute portion of a slide presentation is included. Judy Butler and Elsie French assembled the video and slide presentation for the short course. The video tape is available on loan and is listed in the material section for the Southeastern Media Center for the Deaf. Eight educational institutions from other states have requested and utilized the video tape. This tape is also utilized for educating college students at The University of Tennessee and for visitors interested in our research project.

The remainder of this chapter includes the papers mentioned above.

The convention papers refer to slides that were presented. Only a few of these slides will be included. They will be identified as: figures (slides).

AN EVALUATION OF TWO METHODS
FOR HABILITATING PRESCHOOL DEAF CHILDREN:

THE VERBO-TONAL METHOD IN KNOXVILLE,
AND AN ORAL METHOD IN LEXINGTON, KENTUCKY

Linda N. Woodfin, M.A.
Carl W. Asp, Ph.D.
Department of Audiology and Speech Pathology
University of Tennessee
Knoxville, Tennessee

Paper presented at the
Tennessee Speech and Hearing Association Convention
Gatlinburg, Tennessee
May, 1971

This study evaluated the Verbo-tonal Method as utilized in the University of Tennessee's preschool deaf program with an oral method of deaf education as utilized at the Lexington Deaf Oral School in Lexington, Kentucky. For the purposes of this study the latter method is referred to as An Accepted Oral Method.

The subjects were 6 children enrolled in the Verbo-tonal program (G_1) and 6 children enrolled in An Accepted Method (G_2). The mean age for G_1 and G_2 was 5 years 2 months and 5 years, respectively. The Ss in the Verbo-tonal group had a three-frequency average of 94.2 dB (ISO, 1964) in the better ear. The three-frequency average for G_2 was 90.7 dB (ISO, 1964) in the better ear. The teacher for each group was an adult female with approximately 6-months experience in teaching preschool deaf children.

The criterion measures utilized in evaluating these methods of habilitating preschool deaf children were: (1) the mean 1-9 rating scale of "intelligibility," (2) the number of vocalizations per minute, and (3) the performance score. These measurements were obtained at 3 equally-spaced testing times (T_1, T_2 and T_3) during the 9-month school year.

Speech Samples

A list of 27 test words that were appropriate for the age level of the children was established by both teachers at the onset of the study. Each teacher selected therapy words from the test words according to the particular learning situation and method involved Not all test words were utilized as therapy words. Therapy words were designated as familiar test words; non-therapy words were considered unfamiliar test words. All of the 27 test words were used for obtaining the speech samples at T_1, T_2 and T_3. These speech samples were recorded under the following test conditions: (1) auditory clues without amplification (C_1), (2) visual and auditory clues without amplification (C_2), and (3) auditory clues with amplification (C_3). The auditory with amplification condition (C_3) was utilized only at T_3. For both auditory conditions (C_1 and C_3), the teacher was positioned behind the child. In the visual-auditory condition (C_2), the teacher was positioned in front of the child. For C_1, C_2 and C_3, the teacher stimulated the subject with the 27 test words in random order. The speech samples from the three test conditions were recorded, randomized, and judged by "normal-hearing" college students who utilized a psychophysical rating scale of 1-9.

The analysis of variance of the speech samples revealed no significant differences between the groups when T_1, T_2, and T_3, and C_1 and C_2 were evaluated. However, at the final period of testing when the three conditions were analyzed together, the Verbo-tonal group's ratings were significantly better than the Accepted Oral group's scores for the familiar test words. At T_3 the Verbo-tonal group received significantly better auditory (C_1) and auditory with amplification (C_3) scores than G_2.

In almost all instances without amplification, the visual-auditory scores (C_2) received significantly better ratings than the auditory condition (C_1) for both groups. Both the auditory and visual-auditory scores improved significantly as a function of time.

At the final testing period, the Verbo-tonal group's scores for the auditory with amplification condition (C_3) were significantly better than the visual auditory (C_2) condition without amplification. The Accepted Oral group's visual auditory scores were significantly better than their intelligibility ratings for C_1 and C_3. When amplification was added to the auditory condition, both groups improved significantly.

The results of the Pearson product-moment correlation coefficient indicated that the judges agreed with each other and also were capable of making similar judgments on the same samples at a later time.

Classroom Vocalizations

Ten 30-second samples of vocalizations for each child were obtained during the following conditions: (1) reading readiness (RR), and (2) group free play (FP) activities. These samples were obtained for four consecutive days for each test period.

The results of the analysis of variance revealed there were no significant differences between the groups. For both groups the rate of vocalizations per minute increased as a function of time. The deaf children in both groups were significantly more verbal during the free play condition.

Recorded Vocalizations

For this criterion measure, the children were stimulated with 8 toys common to both groups for 2.6 minutes at each of the 3 testing times. The results revealed that the Verbo-tonal group was significantly more vocal than the Accepted Oral group. The Verbo-tonal group also vocalized more than the Accepted Oral group as a function of time. The rate of vocalizations per minute increased as a function of time for the Accepted Oral group, but the differences were not significant.

Performance Scores

For this criterion measure 10 objects were placed on a table in front of the child. The child was instructed to respond to the phrase, "Give me the __________," by placing the object in the teacher's hand. The object was then returned to the table. The child received 1 point for each correct response; it was possible to score a total of 10 points.

When considering the performance scores for each group for T_1, T_2, and T_3, the mean scores for the two groups were not significant. However, at T_2 and T_3, the mean performance scores for the Verbo-tonal group were significantly better than the Accepted Oral group's scores.

A STUDY OF THE PERCEIVED PITCH OF 23 ENGLISH CONSONANTS

Mary McClanahan Peterson *
Department of Audiology and Speech Pathology
University of Tennessee
Master Thesis, 1971

ABSTRACT

This study investigated variations in the pitch of 23 prevocalic English consonants as perceived by 23 normal-hearing adult listeners. The consonants were combined in pairs (e.g., pɑ-sɑ) and ordered on a tape according to the method of paired comparisons. The listeners were instructed to mark on an answer sheet which consonant of the pair was higher in pitch. Each listener rated 253 pairs.

Statistical analyses revealed that all 23 listeners were significantly consistent (intra-judge reliability) in their responses and that the agreement among judges (inter-judge reliability) was significant. Significant differences were found to exist among the 23 consonants as revealed by a nonparametric analogue of an analysis of variance. Subsequent tests of difference revealed that significant differences separated the consonants into groups corresponding to low, low-middle, middle, high-middle, and high pitch. Significant differences were found between voiced and voiceless consonants, the voiceless consonants being higher in pitch. The nasals were found to be significantly lower in pitch than both the fricatives and affricatives. Significant differences were found among the places of articulation, but no particular order was apparent.

The responses of all 23 listeners and the 10 most consistent listeners were used to determine the rank ordering of the consonants from low to high pitch. The rank orderings of the consonants of all 23 listeners and the 10 most consistent listeners were found to correlate significantly with Guberina's rank ordering of consonants based on filtered stimuli. The rank ordering of the responses of the 10 most consistent listeners was found to correlate significantly with Poole's norms for speech acquisition. The rank ordering of all 23 listeners was not significantly correlated with Poole's norms. No significant correlation was found between the rank orderings of all listeners and the 10 best listeners and Templin's norms for speech acquisition. Responses to the test stimuli were elicited from a hearing-impaired adult. He was consistently able to rate one of the pairs as being higher in pitch. His responses were significantly consistent, indicating that he could hear differences in pitch among the consonants. No conclusions could be made comparing the responses of a hearing-impaired population with a normal-hearing population due to the smallness of the hearing-impaired sample. see Tables 27 and 28.

It was concluded that listeners can hear differences in the pitch of unfiltered English consonants. Since the results of this experiment were found to be in agreement with the results of experiments on perceived pitch conducted by Guberina using filtered stimuli, it was concluded that each consonant has an inherent pitch characteristic.

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* Submitted as a possible research paper for the 83rd meeting of the Acoustical Society of America, Buffalo, New York, April, 1972. (C. Asp is co-author.)

TABLE 27

OPTIMAL OCTAVES OF ENGLISH (BRITISH) CONSONANTS AND VOWELS AS DETERMINED BY GUBERINA

Frequency	Optimal: English (British)	
	Consonants	Vowels
100 - 200 Hz	-	-
150 - 300 Hz	-	-
200 - 400 Hz	p b	u: u
300 - 600 Hz	w	u ou
400 - 800 Hz	l n	ə: u
600 - 1200 Hz	k g f v m	ɔ: ɔ ʌ
800 - 1600 Hz	t d h l	ɑ: ə ɔi
1200 - 2400 Hz	ð ʒ r dʒ	æ ɛə
1600 - 3200 Hz	ʃ tʃ	i e iə
2400 - 4800 Hz	j	ei ai
3200 - 6400 Hz	-	i:
4800 - 9600 Hz	z	-
6400 - 12800 Hz	s	-

Source: Institute of Phonetics, University of Zagreb, Zagreb, Yugoslavia.

TABLE 28

THE RANKING OF THE PREVOCALIE CONSONANTS IN A PAIRED-COMPARISON STUDY (M. M. PETERSON)

23 Listeners	10 Best Listeners
Consonant	Consonant
n	m
m	g
g	n
ð	b
dʒ	r
r	d
b	w
d	l
w	dʒ
j	v
l	j
p	ð
v	hw
θ	h
t	p
z	k
tʃ	θ
h	f
f	tʃ
hw	z
k	t
ʃ	ʃ
s	s

VARIATIONS IN DETECTION THRESHOLDS FOR FILTERED VERBO-TONAL STIMULI, PURE-TONE STIMULI, AND SPEECH DETECTION THRESHOLDS IN A PRESCHOOL DEAF POPULATION

Todd Harris Porter
Department of Audiology and Speech Pathology
University of Tennessee
Master Thesis, 1970

ABSTRACT

This study investigated variations in detection thresholds for Verbo-tonal stimuli (filtered disyllabic nonsense syllables) and pure-tone stimuli (median frequencies of the octave bandwidths of the filtered disyllables) for preschool deaf children. These thresholds were also compared to the speech detection threshold (SDT). A sonagraphic analysis of the filtered Verbo-tonal stimuli indicated that acoustic energy was present outside the octave bandwidths of the logatomes (nonsense syllables) presented directly from the tape recorder. An investigation was also completed on the effects of re-filtering these logatomes before presenting the stimuli to the listeners.

Ten normal-hearing adults (Group 1) and 10 preschool deaf children (Group II) were used as subjects. The normal-hearing adults were used for the establishment of zero reference levels (ZRL) for the recorded stimuli utilized in this study, while the deaf children served as the experimental group.

A significant difference was found between detection thresholds for logatomes directly from the tape recorder and the same logatomes when they were re-filtered. The detection thresholds for the re-filtered logatomes were lower by 5 - 30 dB in the low frequency range and by 5 - 20 dB in the high frequency range. On the other hand, the detection thresholds for the logatomes directly from the tape recorder were lower by 5 - 10 dB in the middle frequency range. It was concluded that the filtered Verbo-tonal stimuli must be re-filtered before being presented to the listener in order to obtain valid detection thresholds.

No significant difference was found between Verbo-tonal detection thresholds and pure-tone detection thresholds. Despite the lack of a significant difference in the means of the octave bands, a significant difference was found at nine out of 17 frequencies. The detection thresholds for the Verbo-tonal stimuli were lower by 5 - 30 dB in the very low frequency range and by 5 - 40 dB in the very high frequency range. On the other hand, the detection thresholds for the pure-tone stimuli were lower by 5 - 20 dB in the middle frequency range.

The difference found between Verbo-tonal and pure-tone detection thresholds may be related to the following factors: (1) the degree of hearing loss of the subjects, (2) the type of hearing loss of the subjects, (3) the familiarity of the stimuli to the subjects, (4) the age of the subjects, (5) the frequency of the pure-tone stimuli, and (6) the method used in presenting the Verbo-tonal stimuli.

A significant correlation was found between the pure-tone average (PTA) and the SDT, as well as between the logatome average (LA) and the SDT. In addition, a significant difference existed between the PTA and the SDT, as well as between the LA and the SDT. It was concluded that pure-tone detection thresholds and Verbo-tonal detection thresholds are similar with respect to estimating the speech detection thresholds. A correction factor of approximately 17 dB must be subtracted from either the PTA or the LA to estimate the SDT for preschool deaf children.

FIVE ENGLISH VOWELS UNDER ELEVEN BANDPASS FILTERING CONDITIONS AS A TEST OF "OPTIMAL OCTAVES" OF PERCEPTION

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Paper presented at the 82nd Meeting of the
Acoustical Society of America
Denver, Colorado
October 19-22, 1971

Several theories have been advanced to identify the significant parameters in the perception of phonemes. One theory that has received very little attention in the U.S.A. is the one offered by Guberina, a professor at the University of Zagreb. Guberina hypothesizes that each speech sound has an "optimal octave" which provides maximum intelligibility for the perception of that sound. In octaves other than the optimal octave, a sound becomes distorted, less intense, and gives rise either to complete distortion or is identified as another phoneme. For example, if the vowel /i/ is bandpass filtered through the optimal octave for /u/, it will be perceived as the phoneme /u/. If it is passed through the optimal octave for /ɑ/ it will be perceived as /ɑ/, etc. In theory, the optimal octave will determine the phoneme that is identified regardless of the input phoneme or source. He also maintains that optimal octaves are not noticeably affected by the fundamental frequency of the speaker.

Slide 1 displays the optimal octaves for the vowels /u, o, ɑ, e, i/ according to Guberina's hypothesis. The ordinate displays the 5 vowels ranging from /u/ through /i/. The abscissa displays overlapping octave filter bands, ranging from the low bands on the left to the higher frequency bands on the right. As may be observed, /u/ is perceived in the octave bands 150-300 or 200-400 Hz; /o/, in the band 400-800 Hz; /ɑ/, in the band 800-1600 Hz; /e/, in the band 1600-3200 Hz; and /i/, in the bands 2400-4800 or 3200-6400 Hz. The shape of this line should be kept in mind because reference will be made to it later in this paper.

Guberina has developed procedures for habilitation, rehabilitation and audiometric testing of the hearing-impaired. One basic assumption of these procedures is that perception is affected by optimal octaves.

In order to test the hypothesis of optimal octaves, the study reported today utilized two adult speakers, one male and one female, who spoke the 5 English vowels of /u, o, ɑ, e, i/. These vowels were bandpass filtered through 11 overlapping octave bands ranging from the 100-200 Hz band to the 3200-6400 Hz band.

Slide 2 illustrates the instrumentation. The 5 vowels were recorded on a Sony tape recorder, amplified, passed through two variable bandpass filters in series, and re-recorded on the second Sony tape recorder in a randomized order.

Slide 3 displays the output of each octave-band filter condition as measured by a Bruel and Kjaer Test System. The ordinate represents a 50 dB range. Each of the 11 filter conditions is identified at the top of the slide, ranging from number 1 at the left (100-200 Hz) to number 11 at the right (3200-6400 Hz). The roll-off for most of these filter settings is at least 50 dB per octave.

Fifteen normal-hearing college students judged 135 conditions by making a forced choice of one of 5 vowels, and circling the appropriate vowel on the response sheet. Of the 135 conditions, 15 were for the practice session, 110 for the experimental procedure, and 10 for an estimate of intra-judge reliability. The judges were seated in a sound-treated booth, wore TDH-39 earphones, and listened to the stimuli at 70 dB SPL.

The data was analyzed in 2 ways. For one analysis, the responses of the judges were converted to a 1-5 scale, where /u/ equals 1, /o/ equals 2, /ɑ/ equals 3, /e/ equals 4, and /i/ equals 5. For example, if the listener circled the vowel /u/ it was later assigned to the numerical value of 1. This 1-5 scale makes the assumption that the vowels are on

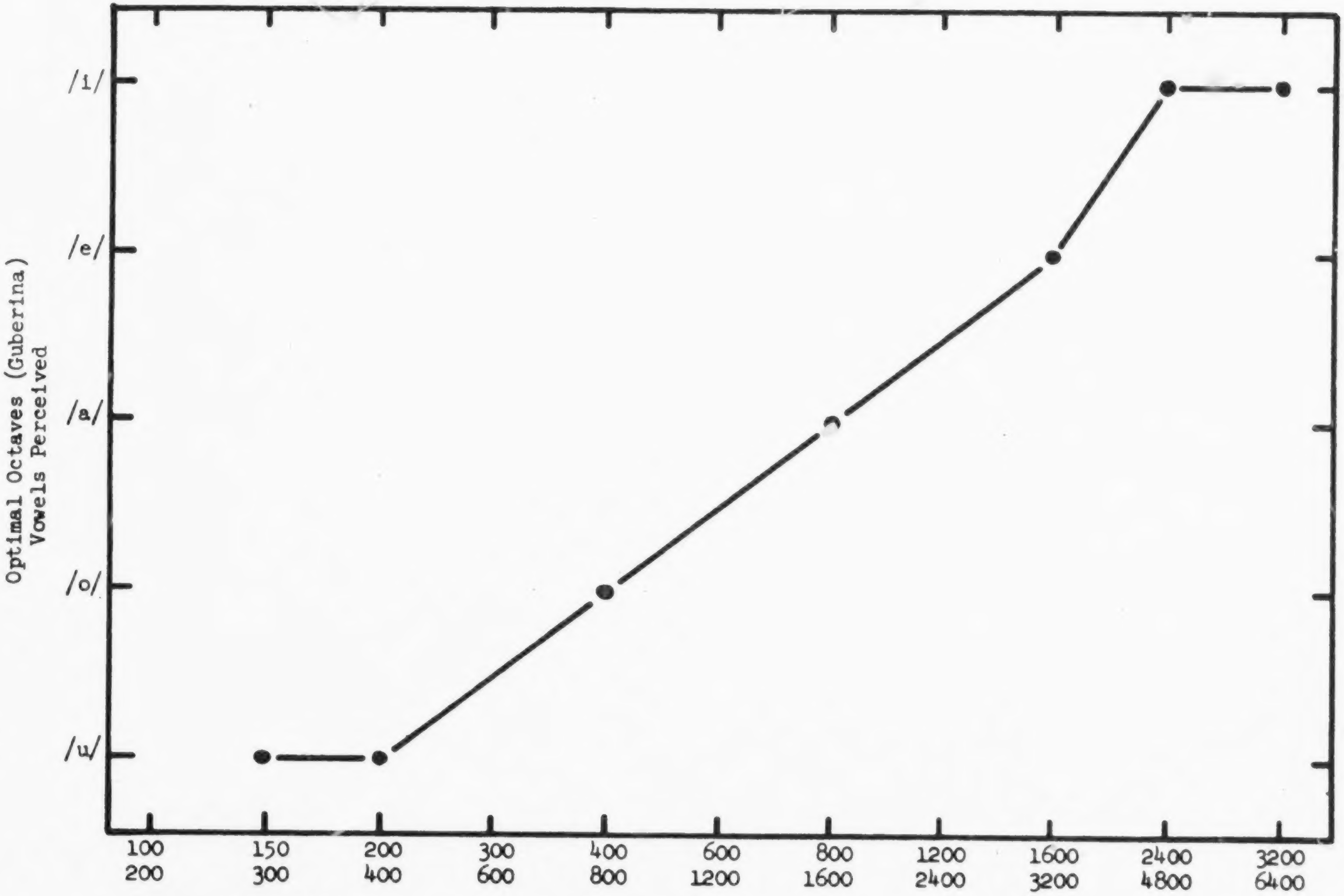

Figure 115 (slide 1).

a "perceptual continuum" (Asp, 1970). The continuum has been constructed according to Guberina's hypothesis that has vowels arranged from /u/, a low-frequency vowel, to /i/, a high-frequency vowel. The 3-factor analysis of variance (Bruning and Kintz, 1968) evaluated 11 filtered conditions, 2 speakers, and 5 vowels. The criterion measure was the number on the 1-5 scale representing the listener's perception for each experimental condition. Slide 4 displays the results of this analysis. The F-ratios of speakers, vowels, and filtered conditions were significant. The following inter-actions were significant: (1) speaker-filter condition; (2) vowel-filter condition; and speaker-vowel-filter condition. The inter-action of speakers and vowels was not significant.

Slide 5 illustrates the mean value for each filter condition used in this study. The format is the same as the format of the first slide with the exception that the 1-5 values are also displayed on the ordinate. As indicated earlier, the responses or circled vowels were converted to the 1-5 scale values. The solid lines connect the points of the mean value for each filtered condition. For the filter conditions above 600 Hz, the data reported in this study is similar to Guberina's hypothetical curve as viewed in Slide 1. However, there is a considerable difference in the means for the filter condition conditions below 600 Hz. The vertical broken lines display the standard deviation for each filtered condition. In general, the standard deviations were larger for the low frequency bands. For example, for the three lowest bands, the perception was usually /i/ or /u/ which are on opposite ends of the 1-5 scale. As a result, the mean value for these filtered conditions was between 3.2 and 3.5 on the 1-5 scale which corresponds to the vowel /a/. So, for these conditions, the means do not accurately reflect the perception of the listeners. On the other hand, the standard deviations were considerably smaller for the mid-frequency range. The most consistent perception was observed for the 2400-4800 Hz and the 3200-6400 Hz bands. For these bands the perception was always /i/.

Another way of viewing these data is according to the male and female speakers. Slide 6 utilizes the same format as the previous slide. The mean ratings for the male speaker are connected by the solid line; the mean ratings for the female speaker connected by the broken line. Above 600 Hz, the responses of the listeners are similar; however, below 600 Hz, there is a considerable separation with the female speaker perceived as higher on the 1-5 scale. For the male speaker, the overall mean rating for all filtered conditions was 3.0, whereas, it was 3.6 for the female speaker. This indicates that the perception of the filtered vowels was affected by male and female speakers, and it would appear that the difference may be a result of the difference in fundamental frequency of these speakers.

As indicated earlier, there was a significant difference for the main factor of vowels. Slide 7 displays the perception as a function of input vowel. The ordinate represents the perception on the 1-5 scale. The abscissa represents the input vowels, ranging from /u/ at the left to /i/ at the right. The solid line connects the mean rating for each vowel for all experimental conditions. As may be observed, the mean ratings increase from 3.0 for /u/ to 3.8 for /i/. According to Guberina's hypothesis, this line should be relatively flat because the input vowel or source should not noticeably affect the perception of filtered vowels.

In the second analysis, the optimal octave was determined according to Guberina's criterion - that is, the octave band where most listeners perceive each vowel. For this analysis, a vowel matrix was constructed for each filter condition as a function of input vowel and perceived vowel.

From these matrices, the optimal octave was determined by selecting the filter condition with the most frequent perception of each vowel. Slide 8 displays the optimal octave or filter band with the most frequent perception of each vowel. The ordinate represents the perceived vowels ranging from /u/ at the bottom to /i/ at the top. The abscissa displays the range of filter bands with the low-frequencies on the left to the high-frequencies on the right. The solid line connects the points for the male speaker, and the broken lines connect the points for the female speaker.

For the male speaker, the vowel /u/ was perceived most frequently through the band 200-400 Hz. For the female speaker, /u/ was perceived most frequently through the 150-300 Hz band. For the vowel /o/, the optimal octave was 400-800 Hz for the male and 600-1200 Hz for the female. For the vowel /a/, the optimal was 800-1600 Hz for both speakers. For the vowel /e/, the optimal was 1600-3200 Hz for the male speaker. For the female speaker, the same vowel had identical values for 3 filter bands (light). For the filter bands 2400-4800 and 3200-6400 Hz the listeners always perceived the vowel /i/ for both speakers.

The solid line for the male speaker is identical with the optimal octaves reported by Guberina's Model for the vowels /u, a, i/ but there is some variation for the vowels /o/ and /e/.

Guberina utilizes "optimal octaves" in the following areas: (1) habilitation and rehabilitation of the hearing-impaired (Verbo-tonal Method); (2) audiometry with filtered speech; (3) speech therapy with normal-hearing patients; and (4) teaching of foreign languages. In therapy, a filtering system is utilized to correct perceptual errors. For example, if a person is attempting to learn a foreign language and perceives /u/ when the stimulus is /i/, the filtering system is adjusted to the "optimal octave" for /i/, which is the 2400-4800 or the 3200-6400 Hz bands. It is hypothesized that the person is more likely to perceive in these bands.

This study attempted to evaluate the concept of optimal octaves by analyzing the data with 2 different procedures. The statistical analysis indicated the mean values above 600 Hz for both speakers were similar to Guberina's hypothesis. On the other hand, the analysis for the matrix indicates the optimal octaves for the male speaker are identical with Guberina's theory for all the test vowels whereas for the female speaker there was not a complete agreement.

(This study was supported by a grant from the U.S. Office of Education.)

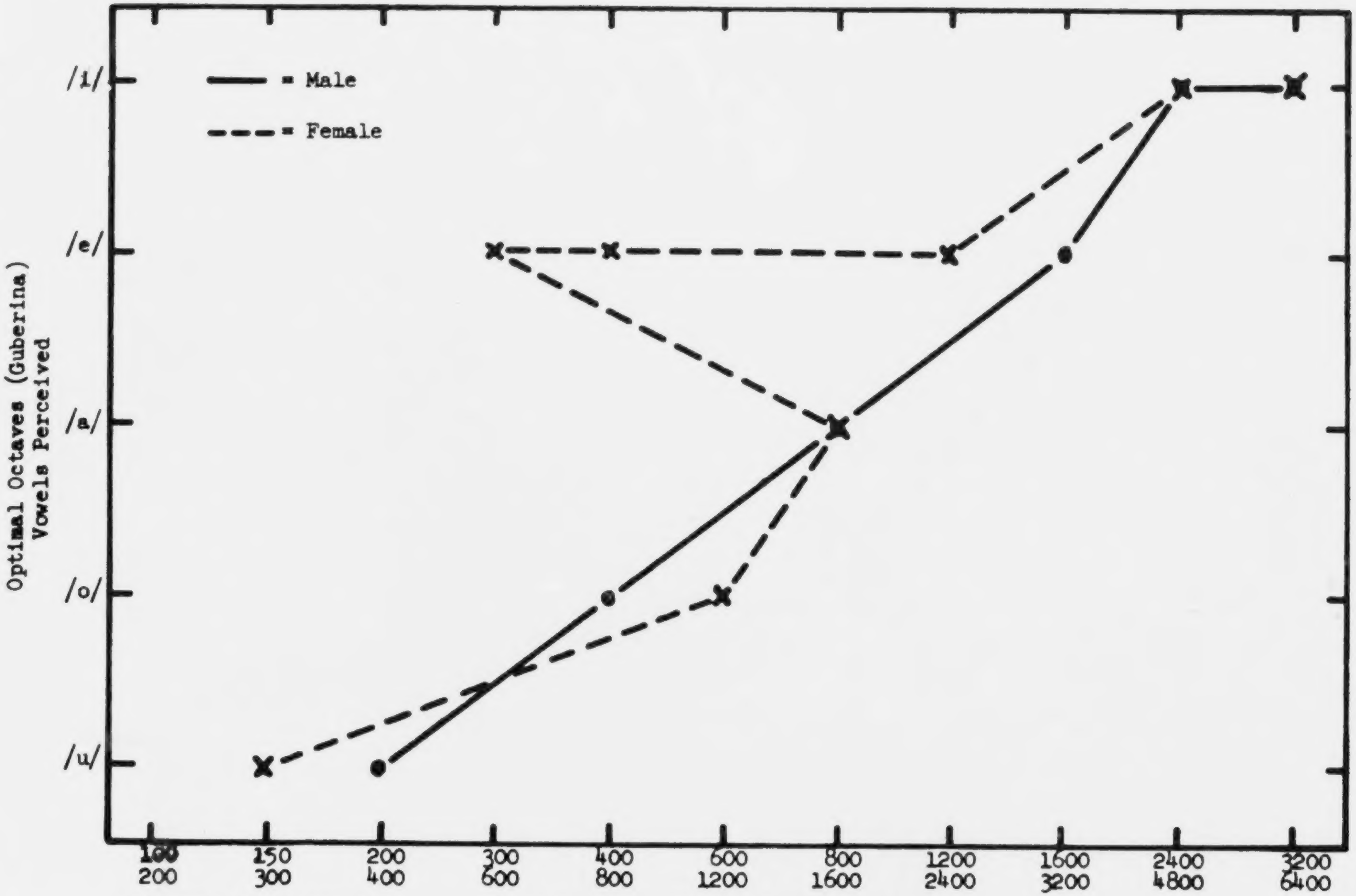

Figure 116 (Slide 8).

MEASUREMENT AND OPERANT CONDITIONING OF THE VOCALIZATIONS OF PRE-SCHOOL DEAF CHILDREN

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Paper presented at the 78th Meeting of the
Acoustical Society of America
San Diego, California
November 7, 1969

The purpose of this study was twofold: (1) to compare the rate of vocalization of deaf and normal-hearing pre-school children, and (2) to evaluate the effectiveness of operant conditioning for controlling and increasing the vocalizations of deaf children.

The subjects for this study were 20 pre-school deaf children and 41 normal-hearing children. The mean age of the deaf group was 4 years 3 months, with an age range of 2 years to 6 years 2 months. The mean age for the normal-hearing group was 4 years 10 months, with an age range of 1 year 11 months to 5 years 11 months.

For the deaf group, the three-frequency (.5, 1 and 2 KHz.) pure-tone average was 86.4 (I.S.O., 1964) in the better ear. The normal hearing group satisfied a pure-tone screening criterion of 25 dB (I.S.O., 1964) at .5, 1 and 2 KHz, bilaterally.

The instrumentation included a voice-operated relay, a throat microphone, a four-digit electro-mechanical counter, an automatic timer, a graphic recorder, a step relay, and an apparatus for visual feedback. The visual feedback was accomplished by modifying and electrically connecting the eyes and nameplate of a stuffed animal. The step relay and the visual feedback were utilized only during the conditioning and re-conditioning periods.

Baseline measures were obtained over a three-month period for the deaf group, whereas for the normal-hearing group, the measures were obtained over a three-week period. Each session for measuring the rate of vocalization was five minutes in length. The mean number of sessions for the deaf group was 10.94 with a range of 4 to 26 sessions. For the normal-hearing group, the mean number of sessions was 4.7 with a range of 4 to 10 sessions.

The criterion measure for the between-group comparison was the mean rate of vocalization per minute for each child. A t-test for independent measures revealed a t-ratio of 2.62 which was significant at the 0.5 level. The mean rate of vocalization for the deaf group was 7.49 per minute, whereas it was 32.17 for the normal-hearing group. The standard deviations were 7.35 and 11.24 respectively. The results indicated that the normal-hearing group produced 25 more vocalizations per minute than the deaf group.

For the operant conditioning procedure, 13 children from the deaf group were selected as subjects based on their regular class attendance. Prior to conditioning an attempt was made to evaluate the effect of adding amplified auditory feedback and a stuffed animal without illumination of the eyes and nameplate. These two factors were introduced for 2 additional 5 minute sessions. The mean rate of vocalization per minute for each of the 13 deaf children served as the criterion measure. A t-test for correlated samples revealed a t-ratio of 0.04 which was not significant.

The mean number of vocalizations for the baseline period was 9.39 per minute and it was 11.22 for the addition of amplified auditory feedback and the stuffed animal without illumination. As a result, it was assumed that any significant increase in the rate of vocalization during operant conditioning could be attributed to the primary reinforcers.

For the operant conditioning procedure, the same 13 deaf children served as subjects. The eyes and the nameplates of the stuffed animal were modified and electrically connected to illuminate when the child vocalized. To avoid extinction during conditioning, candy, peanuts, and trinkets were also utilized as reinforcers. These reinforcers were contingent upon 2 illuminations. In addition, each vocalization was picked up by a concealed microphone amplified by an auditory training unit and was presented to the child via a set of earphones.

At the outset of operant conditioning, a continuous reinforcement schedule (1:1 ratio) was employed. After two sessions had been completed and/or a decrease in vocalization was observed, the experimenter utilized the step-relay to switch a variable reinforcement schedule. The variable schedule included ratios of: 1:1, 2:1, 3:1, 4:1 and 6:1 that were randomized in a series around increasing mean values of 2.5, 3.5, and 4.5. After the vocalizations were maintained for at least two sessions with a mean variable ratio of 4.5, the primary reinforcers (illumination and candy) were withdrawn to permit an extinction period of at least two sessions.

During the extinction period, the stuffed animal remained on the table but it did not illuminate when the child vocalized. Each child received amplified auditory feedback during the extinction period. Measures were obtained during this period to evaluate the effect of removing the reinforcers.

Following the extinction period, a reconditioning period (spontaneous recovery) was employed. The procedure for the reconditioning was identical with that of the conditioning period. For each of these 4 periods, the mean number of 5-minute sessions was 10.94 for baseline, 7.7 for conditioning, 3.0 for extinction, and 2.3 for reconditioning.

To evaluate the effectiveness of operant conditioning, the mean rate of vocalization per minute was computed for each of the 13 deaf children. These mean values served as the criterion measure for a single-factor analysis of variance for repeated measures on the same subjects. The among conditions F-ratio of 25.93 was significant at the .05 level. The groups means were 9.37 for baseline, 34.95 for conditioning, 8.36 for extinction and 34.95 for reconditioning. The standard deviations were: 8.37, 11.53, 8.64 and 10.53, respectively. There was an increase of 25.56 vocalizations per minute during conditioning. Although each subject conditioned at a different rate, 12 of the 13 subjects at least doubled their baseline level. During both the conditioning and the reconditioning periods, the mean rate of vocalization for the deaf group exceeded the mean rate for the normal hearing children. Inspection of the individual graphs indicated that the rate of vocalization of each deaf subject returned to the baseline level during the extinction period.

A Duncan Multiple Range Test was employed to test for significant differences between the conditions. The results indicated a significant difference between baseline and conditioning, baseline and re-conditioning, conditioning and extinction, and extinction and re-conditioning. In addition, there was no significant differences between baseline and extinction and between conditioning and reconditioning. The results of these analyses appear to demonstrate that the vocal behavior of these deaf children was under the control of the experimenters.

This work was supported by a NIH Biomedical Sciences Support Grant FR-7088

A DISTINCTIVE FEATURE ANALYSIS OF INITIAL CONSONANTS OF PRESCHOOL DEAF CHILDREN WHO RECEIVED VERBO-TONAL THERAPY

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Master Thesis, 1970

ABSTRACT

The purpose of this study was to complete a distinctive analysis of 11 initial consonants that were produced by 14 preschool deaf children who received Verbo-tonal therapy. Speech samples were obtained at an "early" and a "later" point in habilitation of each child. The teacher presented an oral stimulus (word) and the child responded by attempting to imitate the stimulus. In one condition, the teacher was seated behind the child to eliminate visual cues; the second condition included both visual and auditory cues because the teacher was seated in front of the child. Each condition was presented without amplification. The stimulus words contained the following initial phonemes: /p, b, m, t, d, k, g, s, ʃ, tʃ, l/. The oral responses of the children were dependent upon the perception of the oral stimuli (words).

These initial consonants were analyzed in terms of the number of errors (substitutions and omissions) and the number of omissions at both test periods and test conditions. Six distinctive features were utilized to analyze the type of substitution errors. These features were: (1) voicing, (2) nasality, (3) friction, (4) continuity, (5) liquid, and (6) place (bilabial, alveolar, palatal, and velar).

The results of this study are as follows. In terms of articulation errors (substitution and omissions) of initial consonants, the errors decreased significantly from the early to the later test periods. In addition, fewer errors were observed under conditions utilizing both visual and auditory cues for both test periods. These data suggested that the perception and production of initial consonants was improved, and that the availability of visual cues improved the performance of these children even though visual cues were not formally used in therapy.

There was a "slight" increase in omissions as a function of time. When both visual and auditory cues were available, the omissions increased as compared to the number of omissions under the condition with only auditory cues.

The distinctive feature disparity (DFD) between initial consonants of the stimulus and the response decreased slightly over a function of time which suggested a degree of improvement in the type of articulation errors. The smaller DFD under the auditory conditions suggested a closer approximation of the correct sound when only auditory cues were available.

There was no significant correlation between the frequency of the substitution errors and the number of DFD for any of the 11 initial consonants. In other words, the number of DFD followed no predictable order with regard to the most frequently occurring substitutions.

The most frequent feature error for substitutions was voicing. This result was compatable with reports by earlier investigators. Bilabials were the most frequent place error. One explanation was that the bilabials /p, b, m/ were among the first phonemes taught to the subjects, and therefore were more firmly established. In addition, the bilabials are the most visible sounds.

VOCALIZATION RATE OF DEAF AND NORMAL-HEARING CHILDREN

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Paper presented at the 81st Meeting of
the Acoustical Society of America
Washington, D.C.
April 23, 1971

At the 78th ASA Meeting in San Diego, Asp and Lawrence reported on the "Measurement and Operant Conditioning of the Vocalizations of Preschool Deaf Children". One section of the study indicated that normal-hearing children vocalize 25 more times per minutes than preschool deaf children.

As a follow-up to their paper, the study presented today measured the vocalizations of 65 deaf and 48 normal-hearing children that were randomly selected within 5 subgroups according to the ages of 5, 7, 10, 13, and 17 years. The deaf subjects (Ss) attended Tennessee School for the Deaf (TSD) and the normal-hearing Ss attended Knoxville Public Schools.

All of the deaf Ss were full-time residential students at TSD for at least the past 2 years, and had a 3-frequency average (.5, 1 and 2 KHz) of 75 dB or worse in the better ear (ISO, 1964). The number of deaf Ss within each of the five subgroups ranged between 11 and 16.

All of the normal-hearing Ss had passed the most recent hearing screening test, and had demonstrated regular class attendance. The number of normal-hearing Ss within each of the five subgroups ranged between 7 and 12.

The instrumentation included 6 independent FM units. Slide 1 displays one unit which included a one-inch throat microphone (Grason-Stadler, model E7300 M), a FM transmitter-receiver (Olson, RA 626; Katone Receiver) tuned between 96-104 MHz, an electro-mechanical counter, and an automatic timer that was set for five minutes. Slide 2 displays the 6 independent receiver units. Although it was possible to measure six children simultaneously, only three units were utilized to simplify the task of the experimenter. The trigger level of each unit was set to count a value of five for 5-syllable phrase "One thousand-and one".

All measures for both groups were obtained during the lunch period while the Ss were seated in their respective cafeterias. As each S entered, he was fitted with a FM-transmitting unit. Slide 3 is an example. The throat microphone was positioned adjacent to the throid cartlidge, the antenna which was encased as part of the microphone cable was wrapped around the Ss body, and the FM-transmitter (2½" x 2 3/4" x 1") was held in place by an adjustable belt. After the S was seated, the automatic timer of his unit was set for a 5-minute measurement period. For the deaf, the mean number of 5-minute measurement period was 1.9 with a range of 1 to 6. For the normal-hearing subjects, the mean number of periods was 5.6 with a range of 2 to 11. The number of periods was determined by the availability of the Ss.

A two-factor analysis of variance (Winer, 1962) for unequal cell frequency was utilized to test the 2 groups and the five age levels. The criterion measure was the mean number of vocalizations per minute for each S. Slide 4 displays the results of the analysis. The between-group F-ratio of 163 indicated a significant difference between the groups. The F-ratio for the interaction of groups and ages was also significant.

Slide 5 displays the mean vocalizations per minute on the ordinate, and the five age levels on the abscissa. The top solid line connects the mean (x's) for the normal-hearing Ss. The lower solid line connects the mean (dots) for the deaf Ss. The dashed vertical lines represent the standard deviations. The grand mean for the 48 normal-hearing Ss was 23.05; whereas, it was 6.36 for the 65 deaf Ss. In other words, the normal-hearing Ss vocalized 16.69 more times per minute than the deaf Ss.

Because of the significant interaction, a Newman-Kuels test (Winer, 1962) was used. For the normal-hearing groups, there was no significant difference between the five age levels. For the deaf group, the 7-year-olds vocalized at a significantly higher rate than the 10, 13, and 17 year olds.

Slide 6 displays a reliability check on the measures. The solid line represents the vocalization rate of the 65 deaf Ss that was viewed in the last slide. The broken line represents 20 deaf Ss, four at each age level, that were randomly selected from the original 65 Ss and were re-tested nine months later. A Pearson Product Moment Correlation coefficient was computed for the 20 Ss for the test and re-test periods. The coefficient (r) of +.39 was not significant. There appears to be individual variation for the re-test measures; however, the mean rate of vocalization for the five age levels were similar for the 20 and 65 deaf Ss.

In Slide 7, to the left of the vertical dashed line, dislays the data from the Asp-Lawrence study. The top solid line connecting the means (x's) for 41 normal-hearing Ss at 2, 3, 4, and 5 years of age. The lower solid line connects the means (dots) of the 20 deaf for the same age levels. For both of these groups, the experimenter and a child were seated at a table during the measurement periods. The instrumentation included a throat microphone, a voice-operated relay, an electro-mechanical counter, and an automatic timer. The data to the right of the vertical line is the data viewed earlier for the study reported today. In comparison, the vocalization of the normal-hearing Ss that are 2, 3, and 4 years old compares with the data reported today; however, the 5-year olds (left of graph) vocalized noticeably higher than all other age levels.

For the deaf Ss, the 5-year-old preschoolers vocalized more than the 5-year olds at TSD. This may be a result of the emphasis on auditory training for these preschool children.

Because of the significant decrease in the rate of vocalizations of deaf children after 7 years of age, it is imperative that a feedback mechanism be established before age 10, so the level of vocalization will be maintained.

The results of the Asp and Lawrence study utilizing operant conditioning on deaf Ss demonstrated that the level of vocalization could be controlled and increased to a level of normal-hearing Ss. Slide 8 displays these results. The ordinate is the rate of vocalizations per minute. The dashed horizontal line is the mean rate of vocalization of normal-hearing preschool Ss. The solid line connects the means of 13 deaf Ss for the four experimental conditions which are displayed on the abscissa: (1) B=baseline; (2) C= conditioning; (3) E=extinction, and (4) R=re-conditioning. When the Ss vocalized during the conditioning and re-conditioning periods, they received visual feedback by the illumination of the eyes and nameplate of a stuffed animal.

A procedure such as this should be useful in controlling and increasing the rate of vocalization of deaf children. If the visual feedback is paired with auditory feedback that emphasized the residuum of hearing, it may be possible for some of these children to vocalize at a rate that is nearer that of a normal child. With an increased rate that is stable, the teacher may utilize her time in "shaping the speech behavior rather than attempting to get it in motion.

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THE VERBO-TONAL SYSTEM

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Four-hour Short-Course at the American Speech and Hearing Association
Conrad Hilton, Boulevard Room
Chicago, Illinois

November 20, 1971
1:00-5:00 p.m.

CONTENT AND APPROXIMATE TIME SCHEDULE

	TOPICS	TIME
A.	Introduction, Identification, and Developmental History	1:00
B.	Basic Concepts	1:15
C.	Instrumentation	2:15
D.	Audiometry: Diagnosis	3:00
E.	Habilitation	3:20
F.	Rehabilitation	3:45
G.	Video-tape (28 minutes) Prepared by: Judy Butler, Elsie French, Virginia Hochnedel, Carl Asp, Staff at Southeastern Media Center for the Deaf, and Federal Research Grant	4:00
H.	Panel Discussion Moderator: Carl Asp Participants: Elsie French, John Berry and Dianne Vertes	4:30
I.	Audio-Visual Presentation Prepared by: Judy Butler	4:55-5:00

STAFF

Director:
- Carl W. Asp, Ph.D.

Clinical:
- Elsie French, Supervisor
- John Berry, Supervisor

- Cathy Berry, Teacher-Clinician
- Judy Butler, Teacher-Clinician and Media Specialist
- Betty Brady, Teacher-Clinician
- Julie McCallie, Teacher-Clinician
- Patricia Parlato, Teacher-Clinician
- Astrid Shell, Teacher-Clinician
- Janis Shirley, Child Development, Integration Program
- Dianne Vertes, Audiologist

- Linda Stiles, Supervisor, Social Work

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- Virginia Hochnedel, Teacher Aide, Graphics
- Janet Keck, Secretary
- Susan Lee, Receptionist-Secretary
- Norma Myers, Bookkeeper-Secretary

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2. Research Grant with State of Tennessee
   (2 teachers and 1 aide supported)

DEVELOPMENTAL HISTORY

1. Originator, Professor Petar Guberina, Institute of Phonetics, University of Zagreb, Yugoslavia.
    a. Phonetician - Linguist.
    b. Started in 1954 teaching foreign languages.
    c. Perceptual errors in learning a foreign language were errors of native language.
    d. Rhythm and intonation are important; low frequencies.
2. Verbo-tonal Audiometry, 1955-1956.
3. Rehabilitation of adults, 1957.
    a. Habilitation of prelingual deaf a little later.
4. Verbo-tonal System includes 5 areas: Zagreb.

a.	Habilitation	160	(children, 2-16 yrs; 5 hrs. daily)
b.	Rehabilitation	300	(5-10 yrs.)
c.	Diagnosis: Audiometry.		
d.	Speech Therapy	300	
e.	Foreign Language.	600	children and adults
	Total	1360	

5. Verbo-tonal Method applies to the hearing-impaired; Zagreb integrates 25-30% of children with 90 dB or greater hearing loss.
6. Zagreb, large staff (small teacher-child ratio) from many disciplines. (Phonetics, Music, Rhythm, Teacher of the Deaf)
    a. Switch responsibilities.
7. Verbo-tonal used in other countries
    a. France (Center Applied Phonetics), Belgium (Dr. Perier helps difficult ones), Germany, Italy, Romania, etc.
    b. Brazil and Argentina.
8. North America.
    a. 1962-64 (Guberina, 4 months), Ohio State University. (Drs. Black & Stromsta); Asp, 1964-67 (2½ years)
    b. 1965, Toronto, Canada (Mirko Krapez)
    c. 1966, Columbus, Ohio, Alexander Graham Bell School for the Deaf
    d. 1967, University of Tennessee (Preschool and Rehabilitation sections)
    e. 1966-67, Zanesville, Ohio (possibly not functioning at this time).
    f. 1971, Pittsburg, Penn., Western Pennsylvania School for the Deaf.
9. Verbo-tonal Study Tour (Black & Goff) 12 graduate students, 1 teacher, 2 faculty = 15.
10. University of Tennessee 3-day Symposium, May 1-3, 1972. (Mon.-Wed.)
    a. Sponsored by U.T. and U.S. Office of Education.
    b. 20 teacher-trainers of deaf
        1. Travel Expense
        2. Up to $15 per day
    c. Others can be approved to attend at their own expense.
    d. Speakers
        1. Professor Guberina
        2. Dr. John Black - Study Tour and Impressions
        3. Dr. Asp and staff
            (a) Clinical
            (b) teaching at U.T.
            (c) research (behavior and instruments - Bill Dawson
            Jim Keller
11. Office of Education 3-year research grant.

AUDIOMETRY:DIAGNOSIS

1. Rationale; speech in a tonal fashion.
2. Logotomes or nonsense syllables; two syllables for each; used for all languages. /bru; mu; bu; vo; lɑ; ke; ti; ʃi; si/
3. Test bands (18 to 12,800 Hz) for filtered logotomes.

Octaves	A Series	B Series
	18-37 Hz /bru-bru/	25-50 Hz /bru-bru/
I	37-75 Hz /bru-bru/	50-100 Hz /bru-bru/
II	75-150 Hz /mu-mu/	100-200 Hz /mu-mu/
III	150-300 Hz /bu-bu/	200-400 Hz /bu-bu/
IV	300-600 Hz /vo-vo/	400-800 Hz /vo-vo/
V	600-1200 Hz /lɑ-lɑ/	800-1600 Hz /lɑ-lɑ/
VI	1200-2400 Hz /ke-ke/	1600-3200 Hz /ke-ke/
VII	2400-4800 Hz /ʃi-ʃi/	3200-6400 Hz /ʃi-ʃi/
VIII	4800-9600 Hz /si-si/	6400-12,800 Hz /si-si/

4. Tests.
    a. Filtered or optimal detection.
    b. Non-filtered detection (tests the low-frequency hearing (optimal) for habilitation.)
    c. Transfer: low, high, and discontinuous. (passing through unoptimal bands).
5. Thresholds. For normal-hearing, 10 dB between each.
    a. Detection. 0 dB
    b. Distinction. 10dB
    c. Intelligibility. 20 dB
6. Verbo-tonal Audiogram
    a. Generally, 10 dB better thresholds.
    b. More gradual slope than puretone.
    c. Compare results of filtered and non-filtered.
7. Articulation (test to 100 dB) or intelligibility Audiogram
    a. Low, Low-middle, Middle, Middle-high and High words.
        L = 150-400 Hz
        LM = 300-1200 Hz
        M = 800-2400 Hz
        MH = 1200-3000 Hz
        H = 3200-12,000 Hz
    b. Approximately 10 words at each presentation level.
    c. Levels of 5 or 10 dB steps
8. Vestibular Tests. (think vestibular information is important in perception)
    a. Chloric (irrigate the ear).
    b. ENG responses.
9. Other Testing.
    a. Neurological, psychological, pediatric, sociological, etc.

BASIC CONCEPTS

1. Perceptual Parameters (elements). Analyze Response.
    a. Frequency (pitch).
    b. Intensity (loudness).
    c. Time (duration); timing.
    d. Intonation.
    e. Rhythm. (3 beats perceived as one beat)
    f. Tension. (body movements) voiceless more tense; nasals different quality of tension; vowels, closed more tense.
    g. Pause. (provides information)
2. Structure.
    a. Alter the magnitude of the elements to create the optimum structure.
    b. The optimum structure is always changing.
3. Global. Present all elements simultaneously.
4. Optimum.
    a. Is the correct condition or structure for perception at a particular time for a particular person.
    b. Goal is to search for the optimum structure.
5. Perception from the point of view of the cortex; total perception from all channels (visuals, etc.)
    a. Correct errors by altering the elements; work toward auditory perception.
    b. Figure system of errors; small s/n ratio.
6. Optimal Octaves. Perceptual continuum
    a. Each phoneme has an optimal octave for perception.
    b. Perceptual continuum / u, o, ɑ, e, i/; low to high.
    c. Consonants and vowels together.
    d. Normal-hearing vs hearing-impaired
7. Discontinuous perception. /i/ stimulus: (1)200-400 Hz /u/
    (2)2400-4800 Hz /i/
    a. Lows can facilitate perception of highs.
8. Optimal Field of Hearing: need less amplification; avoid physical and physiological distortion.
    a. Most sensitive area; use Verbo-tonal audiogram
9. Transfer (psychological or linguistic level).
    a. Perceptual transfer explains errors.
    b. Learn to perceive all sounds through optimal.
    c. Tests in audiometry.
10. Phonetic Progression; low to high; order of teaching sounds. Developmental Order: (1) child develops low to medium frequency according to optimals; (2) but, /s/ appears before /tʃ/ and /ʃ/ because these are harder to articulate.
    a. Same as development for normal hearing.
    b. Progression in all parameters.
11. Body as a Transmitter and Receiver.
    a. Biological functions low frequencies.
    b. Body as resonator.
    c. Macro vs Micro; muscular generalization.
    d. Rhythm in low frequencies.
    e. Body conduction vs bone conduction.
12. Infrasonics - frequencies below 20 Hz.
13. Voice training; essential for integration with normal-hearing
    a. Rhythm and intonation.
    b. Vibrator to stabilize voice; greater the loss the more peripheral the placement.
14. Six basic principles of the Verbo-tonal System.
    a. Optimal bands of hearing.
    b. Transfer.
    c. Phonetic Rhythms.
    d. Verbo-tonal equipment.
    e. Verbo-tonal audiometry.
    f. Body as a Receiver and Transmitter.

INSTRUMENTATION

1. Suvag I (System Universal Verbo-tonal Audition Guberina).
   - a. Direct; electrical response ½ to 20,000 Hz.
   - b. Low-pass filters (600, 1000, 2000, and 3000 Hz).
   - c. High impedance input (20 meg ohms); low impedance output (4-100 ohms)
   - d. Microphone: four crystal elements in parallel.
2. Suvag II, Model 043; 3 channels.
   - a. Direct, electrical response 20-20,000 Hz.
   - b. Low-pass filters (75, 150, 300, 600, 1000, and 2000 Hz).
     - (1) Left side, there are 0, 6, 12, or 18 dB/octave roll-off.
     - (2) Right side, there are 20 or 65 dB/octave roll-off.
   - c. High-pass filters (3000, 4000, 6000, and 8000 Hz).
     - (1) Right side, there are 0, 6, or 12 dB/octave roll-off.
     - (2) Left side, there are 20 or 65 dB/octave roll-off.
   - d. Peaking filters. (0=75 dB/ octave and 10= 22dB/octave)
     - (1) Low-peaking (75, 150, 300, 600, and 1000 Hz).
     - (2) High-peaking (2000, 3000, 4000, 6000 and 8000 Hz).
     - (3) Roll-off continually variable and simultaneous for both sides.
   - e. Bass and Treble
     - (1) Centered at 1000 Hz.
   - f. Examples of filter settings.
     - (1) 300 (0)⌝⌞ = 7
       3000 (0)⌟⌜ = 5
       Direct = 2
       G.A. = 4
     - (2) 150 (6)╲ = 5
       4000 (6)⌟⌜ = 7
       1000 (5) = 3
       G.A. = 4
3. Suvag Lingua filters set on octaves.
   - a. Optimal octaves for foreign language work.
     23 dB sharp; 15 dB gradual roll-off
4. Mini Suvag
   - a. Body hearing aid; two outputs.
   - b. Power amplifier.
   - c. Vibrator with protector and holder.
   - d. Battery charger.
5. Suvag Vibar
   - a. Use to develop laryngeal control (voice),pitch duration, quality.
   - b. Use earphones after voice is developed.
6. Other transducers
   - a. Use comercially available units (e.g. Koss, K-6 earphones).
7. Verbo-tonal Audiometer
   - a. The audiometer has a tape recorder for presenting pre-recorded filtered logotomes.
   - b. The frequency response of the entire unit should be as wide and flat (linear) as possible.
   - c. A high quality tape recorder with at least a 50 dB s/n is needed.

HABILITATION

- 1. Principles and Stages. Speech always stimulus.
  - a. Phonetic Rhythms.
    - (1) Body Movements.
      - (a) Purpose; teach correct tension articulation
      - (b) Types.
        - (1. Stimulating.
          - (a. Different movements, body tensions.
          - (b. Not "cues" for sounds.
        - (2. Correcting. each child different.
          - (a. Selected on basis of production error.
          - (b. Relates to general tonicity of child.
          - (c. Always related to motor ability of child.
    - (2) Rhythmical (Musical) Stimulations.
      - (a) Purpose.
        - (1. To develop normal rhythm, intonation.
        - (2. To develop auditory memory span.

(a. Syllable only	(b. Words	(c. Definite Content
Example #1	Example #2	Example #3
a boo	um um	Shower shower
ba boo	uma um	Take a shower
boo boo	mu me	Wash your shoulders
ba	mommy	Take a shower

  - b. Phonetical Progression.
    - (1) Parallels normal speech development (L, LM, M , MH, H).
    - (2) Varied according to child's needs. Functional words taught even if child cannot perceive all elements.
    - (3) Perceptual errors accepted if they parallel that of normal-hearing child. Example: "-oup" accepted for "soup".
  - c. Situational Teaching or Implementation.
    - (1) Speech stimuli always presented in meaningful context.
    - (2) Situations (context) vary to allow for carry over and utilization of speech in all situations.
  - d. Group vs. Individual Therapy.
    - (1) Group.
      - (a) Stimulation of speech production and language concepts.
      - (b) Activities directed toward "total child development" (art, reading readiness, motor skills, etc.).
    - (2) Individual.
      - (a) Auditory Perception.
        - (1. Stimulation.
        - (2. Correction.
        - (3. Evaluation.
          - (a. Aided.
          - (b. Unaided.
  - e. Channels of Perception.
    - (1) Multisensory stimulation.
      - (a) Auditory.
      - (b) Visual.
      - (c) Tactile.
      - (d) Kinesthetic.
    - (2) Lipreading not taught formally, but normal visual clues are available.
    - (3) Final emphasis on auditory; transfer perception to auditory channel.
  - f. Unaided Stimulation
    - (1) Purpose. (another channel)
    - (2) Procedure.
      - (a) Distance.
        - (1. Ear level; both ears, behind the head.
        - (2. Increase distance.

- (b) Type of material.
  - (1. Prepared (e.g., Nursery rhyme).
  - (2. Semi-prepared (story).
  - (3. Unprepared (random).
- (c) Familiarity of material.
  - (1. Familiar.
  - (2. Unfamiliar.
- (d) Vocabulary.
  - (1. Words.
  - (2. Phrases.
  - (3. Sentences.

g. Integration.
- (1) Therapy goal is integrating the child.
- (2) Allows child to function in "hearing world," with or without hearing aid.

2. Implementing Principles at Different Stages of Development.
   - a. Stages of development.
     - (1) Stimulus - speech stimulus is presented to child through bone oscillator, earphones, or both; stimulus is always speech.
     - (2) Awareness of the stimulus.
     - (3) Association of the stimulus to objects.
     - (4) Symbolization - words and sentences.
   - b. Auditory Input.
     - (1) Awareness.
       - (a) Timing (recognizing long vs. short); tension.
     - (2) Vocal Output.
       - (a) Aware of the use of vocalization.
       - (b) Vocalizations become meaningful.
       - (c) Motivated to communicate through vocal output.
   - c. Babbling.
     - (1) Teacher plans only globally.
       - (a) Stimulates with wide range of sounds in a situation.
       - (b) Reinforces sounds that the child produces.
       - (c) Teacher stimulates according to the normal speech development of hearing child. Using more low-frequency sounds, but not excluding middle and high. The child responds according to his stage of perception.
     - (2) Body Movements.
       - (a) Implemented through teacher's manipulation of toys and objects in a situation. The situation is meaningful because you are communicating on the child's perceptual level.
       - (b) In the first stage of stimulating body movements, the child is always stimulated in a situation.
     - (3) Rhythmical or Musical Stimulation.
       - (a) The first stage of musical rhythms are made up of syllables without meaning.
     - (4) Role Playing.
       - (a) The child uses his own sounds to communicate in a meaningful situation. These are reinforced.
     - (5) Unaided.
       - (a) Stimulate the child with sounds that he is producing and perceiving.
       - (b) Throughout the babbling stage the child takes the structure that he needs at that particular time from the global presentation. This structure can vary from day to day. He develops many different sounds which he uses by repeating or babbling them over and over in a meaningful situation.

d. Symbolization (Words to Sentences).
  (1) Words. The next step is to take these elements (babbling sounds) and structure them into 1-syllable (element) words that are meaningful.
    (a) Teacher plans according to the Phonetical Progression.
      (1. Stimulates child with low-frequency 1-element words in a meaningful situation.
      (2. Only the sounds that are produced correctly are reinforced.
    (b) The second stage of body movements is to stimulate and correct speech production by altering the tension and timing of articulation.
    (c) The second stage in rhythmical stimulation is made up of syllables which introduce words with meaning.
    (d) Role Playing.
      (1. The child begins to utilize spontaneous single element words that are meaningful.
    (e) Unaided.
      (1. Use words the child is able to perceive.
  (2) Sentences.
    (a) Increase the number of elements the child can perceive by using all of the above procedures.
    (b) Stimulate the child with words he can perceive in sentences.
    (c) Body Movements.
      (1. As a child advances along the phonetical progression, body movements become more free and are connected only to the rhythms and intonations. The corrective body movements are used only as new sounds are introduced.
      (2. The final goal is intelligible speech with the aid of body movements.
    (d) Rhythmical or Musical Stimulus.
      (1. Increase the auditory memory span for nursery rhymes.
    (e) Role Playing.
      (1. The child acts out a situation with a speech communication; conversation is encouraged.
    (f) Unaided.
      (1. Utilize sentences that he can produce.
      (2. Increase distance of unaided ear.

e. Integration.
  (1) The older children are placed with normal-hearing children the second half of the day.
  (2) This environment stimulates spontaneous speech and develops perception.
  (3) The communication ability of the children is evaluated and changes are made as needed.

REHABILITATION

Hard of Hearing: 1. Functional cases - perceive at 15 ft. (unprepared and unfamiliar)
2. Not functional will need hearing aid.

1. Therapy Schedule.
   a. Individual work; usually three ½-hour sessions per week.
2. Units.
   a. Suvag I: Direct or low-pass.
   b. Suvag II: Direct, Low-pass, High-pass.
3. Transducers.
   a. Earphones (e.g., Koss, K-6).
   b. Bone Vibrator (Suvag Vibar): vibrator is placed in optimal location, e.g., under earphone headband or held in hand. The more severe the loss the more peripheral the placement.
4. Determine optimal field of hearing.
   a. Check pure-tone and Verbo-tonal audiograms.
   b. Adjust Suvag II and filter speech signal through the most sensitive areas as indicated on the audiograms.
   c. In theory, the optimal field of hearing should improve perception.
   d. If necessary, adjust Suvag II based on type of perceptual errors.
5. Expand the optimal field of hearing and work toward a hearing aid. (when extend optimal, need more amplification).
   a. Suvag I - Direct.
   b. Suvag I - Low-pass.
   c. Suvag II - Low-pass.
   d. Suvag II - Discontinuous.
   e. Suvag II - Reduce low-frequencies and move toward speech frequencies.
   f. Suvag II - With hearing aid microphone and hearing aid receiver.
   g. Fit hearing aid to optimal field of hearing.
6. Therapy Material - select material that has the degree of difficulty that is appropriate for the patient.
   a. Stimuli - phonemes, syllables, words, phrases, and sentences.
   b. Type of material.
      (1) Prepared - patient works within a closed set and will know the possible choices.
      (2) Semi-prepared - patient will know the theme or story of the presentation.
      (3) Unprepared - the material will constantly change to increase difficulty of perception.
   c. Conditions.
      (1) Work toward a condition of auditory clues only. Cover face or turn patient around.
      (2) Only include visual clues for very difficult cases or if a patient cannot perceive a certain word.
7. Unaided Stimulation.
   a. Near the end of each therapy session stimulation is to the unaided ear (no amplification) in free-field situation.
   b. All presentations are at a normal conversational level.
   c. Distance is increased until patient does not perceive correctly, then, decrease distance to correct perceptual error. If the patient is successful, return to the distance used earlier.
   d. For cases who can perceive at 15 ft. or greater, a hearing aid may not be needed.

8. A typical session with a hard-of-hearing patient with an acquired hearing loss.
   a. Suvag I with bone vibrator under earphone headband. Earphones not connected. Therapist reads from text with short phrases. Patient repeats each phrase. Therapist repeats a phrase, and corrects if necessary. Approximately 10 minutes.
   b. Suvag II adjusted to optimal field of hearing and presented through earphones. Bone vibrator also connected if needed. Therapist and patient same as above. Approximately 10 minutes.
   c. Unaided ear stimulation. Familiar material is presented and distance is increased. Approximately 5 minutes.
   d. Therapist writes result of the session, identifies specific conditions used, indicates perceptual errors, and make recommendations for next session.

The Verbo-Tonal Method
as Utilized at the
University of Tennessee
for
Teaching the Hearing-Impaired

(This is the audio script for a 28 minute video-tape recording)

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The Verbo-tonal System encompasses five main areas: habilitation and rehabilitation of the hearing impaired, speech therapy with normal hearing, teaching foreign languages and special audiometric tests. This System was developed by Professor Petar Guberina of the University of Zagreb, Yugoslavia, in 1954. Professor Guberina, a phonetician-linguist, began as a teacher of foreign languages. He was interested in the perceptual problems in learning to speak a foreign language. The Verbo-tonal Method for teaching the hearing impaired was an outgrowth of this interest. From the beginning in Zagreb, the Method has been extended to six European countries, two South American, and two North American countries. In North America, Centers have been established in Columbus, Ohio; Pittsburgh, Pennsylvania; Toronto, Canada; and Knoxville, Tennessee.

In Knoxville, the Verbo-tonal Method was implemented at the pre-school level in 1967. The program now serves 25 pre-school deaf children with each child able to receive 15 hours per week. A rehabilitation section has been added and includes a case-load of 20 people. At U. T., our service program for the hearing impaired is combined with course work for teacher training and on-going research to evaluate the clinical and theoretical aspects of the method. Parent counseling is an integral part of the program. In addition, our older deaf children are placed with normal hearing children for the second half of the day and are supervised by child development personnel.

Instrumentation for the Verbo-tonal System involves the following units: three auditory training units, Suvag I, Suvag II, and Suvag Lingua; a bone vibrator (Suvag Vibar); and audiometer; and a hearing aid (Mini-Suvag). Of the training units, Suvag I has an extended low- and high-frequency response that is utilized mostly in classroom work. For individual work, Suvag II is a multi-channel unit with numerous possibilities of filtering the speech signal to the "optimal" frequency response for each child. Suvag Lingua also has a filtering system that is set for the octave bands for teaching foreign languages. Output transducers include headphones and/or bone vibrators. The vibrator is placed on the head or on peripheral areas of the body that are optimum to facilitate perception.

The Verbo-tonal Audiometry differs from conventional pure-tone and speech audiometry. It utilizes nine nonsense syllables or logatomes as stimuli. These logatomes are arranged with combinations of low-pitched consonants and vowels, such as mu-mu and high-pitched ones such as si-si. These logatomes are presented under unfiltered and filtered conditions. The filtered tests employ the optimal octave for each logatome and extends from the 50 to 100 Hertz band to the 6400 to 12,800 Hertz band. Thresholds of detection and intelligibility can be obtained. Measurements of low-, high- and discontinuous-transfer are included. In addition, unfiltered words are arranged according to low-, middle- and high-pitched phonemes. These words are presented in increasing 5-decibel steps above speech reception thresholds to obtain a discrimination curve of perception.

The Mini-Suvag hearing aid has an extended low- and high-frequency response similar to the Suvag I. The hearing aid is fitted as soon as the child can produce and perceive speech sounds. The type or frequency response of the aid is selected to satisfy the needs of each child. The emphasis is placed on the most sensitive area of hearing.

In the habilitation of prelingual deaf children, the Verbo-tonal Method initially utilizes multi-sensory stimulation to develop the perception of speech. In the visual channel, formal lipreading is not taught, but the "normal" visual clues of oral communication are available. Once the child produces and perceives words, he then learns to read and write these words. Improving auditory perception involves teaching the brain to perceive speech with the limited acoustic information that is available. The Verbo-tonal Method recognizes the parameters of perception as: frequency -- intensity -- time or duration -- rhythm -- intonation -- pause and tension. Gross sound discrimination, such as discriminating the sound of a drum from that of a bell, is not utilized. The stimulus is always speech -- which is presented as syllables, words, phrases, or sentences, depending upon the stage of development of each child.

Stimulation with amplification is provided through the Suvag amplification system. Stimulation without amplification is also a vital part of habilitation and rehabilitation. Near the end of each session, the child or adult is stimulated on the unaided ear. At first, the teacher speaks directly into the ear with low-pitched syllables or words that are familiar. Later, more difficult speech material is used that includes high-pitched phonemes. In addition, the distance is increased for each unaided ear with the teacher maintaining a normal conversational level. The goal is to develop unaided auditory perception to its maximum. Helen S. is a 5-year old, congenitally deaf child with a 105 decibel hearing loss in the better ear. After 2 years of daily therapy sessions, Helen can perceive low-pitched sounds at a distance of approximately one foot -- without amplification.

For tactile and kinesthetic stimulation, phonetic rhythms, which include body movements and rhythmical stimulations, are utilized to improve speech production and auditory perception. No traditional facial manipulations or phonetic placement is used. Rather, body movements emphasize different body tensions for correcting articulation. These movements help demonstrate that voiceless sounds, for example, are more tense than voiced sounds. Body movements are utilized for stimulation and correction. For stimulation, different movements are utilized so that a certain movement does not become a "cue" for a certain speech sound or word. For correction, the body movement is selected on the basis of the production error, and depends on the general tenacity of the child. For example, the more tense movements are utilized if the child lacks tension for articulation. Musical -- also called rhythmical stimulations -- are utilized to develop "normal" rhythm and intonation. It also helps the child to develop an auditory memory span which is essential for communicating with phrases and sentences.

In introducing speech sounds to the children, a phonetic progression is followed. It begins with low-pitched sounds like "ba" and "boo", then progresses to high-pitched sounds, like "see" and "she". This parallels the same order to speech development as for normally hearing children. Functional words are selected and the progression is modified to meet the needs of each individual child.

How is auditory perception developed? First, the speech stimuli are presented under controlled conditions and the child must learn to be aware of the auditory sensation. The child is "conditioned" to respond. The child is also conditioned to vocalize. Then, the child will begin to discriminate some parameters -- such as duration, pitch and rhythm. To enhance perception, the stimulus and response are analyzed in all possible parameters. The magnitude of each parameter is evaluated and changes are made based on the type of perceptual error. The goal is to provide the optimum structure of these parameters to obtain the correct perception. For example, increasing the duration and tension of a particular stimulus may be an "optimal" condition for a particular child at a particular time. Through speech stimulation by the teacher the child imitates what he perceives. Through babbling, with teacher reinforcement, he uses and modifies these sounds. Body movements which are appropriate to the babbling sounds are used in manipulating toys. As the perception of phonemes and words are developed, the child begins to associate words with objects or concepts. The difficulty of the stimuli increases until the child can perceive phrases and sentences.

Is language a part of the Verbo-tonal Method? Yes, because speech stimuli are always presented in a meaningful situation. This is referred to as situational teaching, and is an integral part of all learning levels. The teacher has to continually develop situations which are appropriate for new words. This allows the speech to be meaningful and encourages the child to utilize it. Then, the child develops necessary language skills for oral communication.

The children work in both group and individual situations. Group work is primarily for the stimulation of speech production and language concepts. Individual therapy is spent working on any aspect of group therapy with which the child is having unusual difficulties.

For rehabilitation cases, the patients are scheduled for three 1/2 hour sessions per week. The Suvag II unit is used as soon as the optimum field of hearing can be detected. Unaided stimulation is the last part of each session. Hearing aids are fitted if needed at the final stage of rehabilitation. For hard of hearing children and adults, noticeable improvement can be demonstrated in one to three months. For example, in two months, a 65-year old woman increased from 82% to 96% in PB discrimination scores with no change in pure-tone thresholds. Cindy L. is a 4-year old child with a severe hearing loss in the high frequencies and a 64 dB hearing level in the speech frequencies for the better ear. After three months of therapy, Cindy can perceive words and phrases in an unaided condition at a distance of approximately 9 feet.

The Verbo-tonal Program as utilized at the University of Tennessee is an on-going research program to evaluate and determine clinical procedures for the hearing impaired so they may function independently in the normal hearing world.

THE AUDIO-SCRIPT OF A 5-MINUTE SLIDE PRESENTATION AT THE ASHA CONVENTION, NOVEMBER, 1971

Ask any educator about the monumental task of teaching -- and the response will usually be -- "it is a rewarding satisfying experience but not without frustrations".

Teaching the hearing-impaired child will elicit this same response -- shouted with even greater vigor. The rewards are great -- when you see discovery in a child's eyes; pleasure in a task accomplished; new experiences -- that sometimes make your eyelashes feel a little soggy.

But with satisfaction also comes frustration: when one unsuccessful attempt follows another and you know the sun is going behind a cloud; when you have to say ... "no that's not right -- try again" -- and "try again" becomes the incidental teaching.

It's out of the frustrations and the successes that we find new teaching methods.

At best, Education is a dynamic process -- constantly changing -- retaining that which is good and discarding that which is worthless. The Verbo-tonal approach is trying to change those things which do not work in order to find those which do.

The Verbo-tonal approach is trying some things which aren't traditional: a family of instruments which provide a wider frequency response; body movements to stimulate and correct articulation; and a phonetic progression.

Many falitious ideas have sprung up about this method in its short existence in the United States. One is that it stimulates the growth of new hair cells. The growth of language is, in fact, stimulated through the use of residual hearing, but new hair cells are not generated. Another erronous assumption is that deafness is charmed away ... "that all deaf will miraculously hear". What the Verbo-tonal Method at the University of Tennessee does try to do is train the hearing-impaired person to use the hearing he may have.

The present age is one of searching -- exploring, and questioning existing philosophies and techniques.

From your vantage point you can see a variety of teaching techniques -- and depending on how close you are willing to explore them, you determine your own degree of acceptance.

We are quick to ridicule things which are foreign or unfamiliar -- at first glance it may appear that some teachers are dedicated to methods and techniques bordering on the absurd -- while a more thorough examination yields new appreciations, and new insight concerning ageless problems.

The best way to understand a particular approach is to read about all aspects of it and also to see it in action -- talking with the people involved -- observing and evaluating the children -- these are ways to avoid erroneous conclusions.

We find ourselves in an age of electronic sophistication -- but we are still combating problems which have plagued mankind for centruies -- the hearing impaired.

CHAPTER XI
READING PROGRAM

In our Preschool Deaf Program at the University of Tennessee, we attempt to identify hearing-impaired children at a young age and to schedule regular therapy sessions as soon as possible. These group therapy sessions require up to three hours daily and continue until the child is six years of age. At six years of age we refer the child to another educational institution, and there are three possible avenues of referral. These include the following: (1) a regular public school classroom with normal-hearing children; (2) special classes for hearing-impaired in day programs; and (3) a residential school for the deaf.

The Verbo-tonal Method is designed to integrate deaf children into the regular public classroom if the child has developed sufficient auditory perception and speech production to communicate with normal hearing children. In our work at the University of Tennessee, we have found that some of our children are ready at six years of age, but most of them are not. However, if the children remained on this intensive training program until eight or nine years of age, a larger percentage could be integrated into public schools.

Because our work has been limited to the preschool level, we have not been able to develop educational programs to evaluate whether our children could achieve a higher educational level as a result of the Verbo-tonal Method. One such pilot study was undertaken. During the summer session, 1971, Mrs. Patricia Parlato, a full-time teacher in our program, conducted a 6-week reading program to evaluate the reading abilities of four of our children. It was hypothesized that children who have developed auditory perception and speech production will read at a higher level, and that their reading errors will be related to their errors of auditory perception. This pilot study utilized only four children, but it clearly demonstrates the potential for reading after auditory skills have been developed.

The following describes the study conducted by Mrs. Parlato. This study will also serve for satisfying the theses requirement for a master's degree in our department.

THE RELATIONSHIPS BETWEEN AUDITORY PERCEPTION AND READING SKILLS IN 6 AND 7 YEAR OLD PRESCHOOL DEAF CHILDREN

Patricia Parlato, B.S.

Introduction

Many investigators have reported the low reading levels of children with hearing impairments (Wrightstone, Aronow, and Moskowitz, 1963; Rosenstein and Lerman, 1965; Furth, 1966)*. To obtain a better understanding of these reading problems, it may be helpful to review the three language systems that are identified as oral communication, reading, and writing (Myklebust, 1954). Myklebust and Johnson (1954, 1960, 1962) state that in early language development, a child's experiences are first integrated into a nonverbal inner language. At this point in language development, revisualization and reauditorization are used as symbols to represent experience due to the lack of acquisition of a verbal system. After the development of inner language, a child develops a verbal system of receptive and expressive oral language to represent the same experiences. Myklebust (1954) states that the first system acquired phylogenetically and ontogenetically is the receptive language system of the spoken word acquired through the development of auditory perception. Expressive verbal communication is later developed on the perceptual base of spoken language. Myklebust concluded that reading and writing are language systems superimposed on the basic auditory language system. Reading is viewed as a visual, receptive language system and writing as the visual, expressive language system. Developmentally, a child first learns to comprehend and use the spoken language system before learning to read and write.

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*List of reference may be found in "References: Articles in Text" later in this report.

It becomes clear that a hearing-impaired child must learn the primary language system before attempting the higher language systems of reading and writing. The low reading achievement of hearing-impaired children may be viewed as the result of these children not adequately learning the oral language system. The hearing child develops the basic language system primarily through the sensory channel of audition. The development of auditory perception for speech, an immersion into a verbal environment, and possibly the innate potential for humans to develop communication allows the hearing child to understand and become fluent in oral language. Traditionally, the training of hearing-impaired children has not attempted to auditorily simulate the hearing child's development of communication. The residual hearing was not thought to be functional for learning the primary language system. The educational philosophy of deaf education in this country has emphasized non-auditory channels as the primary input system for learning communication. The philosophy of by-passing the impaired sense and teaching to the intact senses is generally followed. The writer concluded that any method of habilitating hearing should allow the hearing-impaired child to more closely duplicate the hearing child's acquisition of speech and language. If the hearing-impaired child is able to learn the primary language system through audition, the processes in learning to read should also be more easily and naturally acquired.

Purpose

There appears to be a need to investigate the reading skills of hearing-impaired children who are learning verbal communication primarily through audition. As a result, this study was designed to evaluate the reading ability of six-and seven-year old hearing-impaired children learning verbal communication through the Verbo-tonal Method. The following questions were under test: (1) Is there a relationship between the perception of speech sounds and the ability to learn to read words containing these speech sounds? (2) Are these children successful in learning to read using the Peabody Rebus Reading Program (PRRP)? (3) Is there a relationship between the number of phonemic reading errors and the child's general intelligibility of speech production?

Subjects

The population utilized for this study consisted of S8(Sa), S9(Sa), S11(Sa), and S14(Sa) who had received Verbo-tonal therapy at the University of Tennessee Preschool Deaf Program. These four children were selected because they were ready to learn to read and were successful in developing verbal communication through audition. The group consisted of two males and two females who ranged in age from six to seven years; the mean age was 6 years, 8 months. Each child had received approximately three years of Verbo-tonal therapy. The total number of therapy hours for each child at the outset of this study was as follows: 939, 760, 799, and 940, respectively. The mean number of therapy hours for the group was 859 hours. All of the children were reported as having prelingual hearing impairments as determined by early audiological testing and case history information concerning speech and language development. The three-frequency average (.5, 1. and 2 KHz) for pure-tone detection in the better ear for each subject was 91, 61, 66, and 90 dB respectively. Appendix A includes the audiograms of these children. The mean three-frequency average was 77 dB. The children were issued Mini Suvag hearing aids in December, 1969. These were worn approximately six to twelve hours daily as reported by the mothers. All of the children appeared to have normal intellectual abilities as measured by the Leiter International Performance Scale. The reader is referred to Table 3 for pertinent information on each subject.

Testing Prior to the Peabody Rebus Reading Program (PRRP)

Subjects were administered the three tests prior to beginning the reading program. A phonemic-perception test of 24 English consonants was developed for this study. Twenty-two English consonants were arranged with the neutral vowel /ə/ and tested in the initial, medial and final position. Two consonants were tested in the initial or final position. The test required a total of 68 responses from each child. It was administered individually with each child wearing earphones and receiving the test stimuli through a Suvag I auditory training unit. The tester was seated in front of the child to allow "normal" visual clues as well as auditory information. It was felt that the auditory-visual condition for perception more closely duplicated normal conditions under which all children learn to read. Each child was instructed to repeat the test stimuli. Practice words were presented until the child understood the testing procedure. A child's response was judged as follows: (1) correct (+). i.e., normal intelligibility of the phoneme;(2) slight distortion (D'), the phoneme was still intelligible but slightly distorted; and (3) incorrect (-), the phoneme was either omitted, another sound was substituted or it was not intelligible due to gross distortion. Each child's responses were transcribed by the tester as well as being recorded on a Wollensak tape recorder. The test was scored according to percentage in each of the three categories of correct, slightly distorted and incorrect. The purpose of this test was to evaluate the perception and production of each child prior to the reading program and to utilize this information in comparison with the phonemic errors made in reading.

The second test included 68 Rebus symbols from Workbook One and Two of the PRRP. This test was administered under the same conditions as the phoneme test. Each Rebus symbol was placed on a separate three-by-five card. The child was asked, "What is this?". The child's response was scored as correct (+) or incorrect (-). A response was correct if the child correctly articulated or approximated the word the Rebus symbol illustrated. A response was judged correct if the rebus elicited a correct associative response such as "happy birthday" for cake and "puppy" for dog. Perceptual accuracy was not considered as a criteria for a correct response. The purpose of this test was to establish how many of the Rebus symbols had natural association prior to the reading program.

A Peabody Rebus Reading Test was the third test to be administered in order to establish a basal level of performance for each child on the PRRP. The test was presented under the same conditions as the previous tests. The Rebus included four subtests. Each subtest consisted of four consecutive frames throughout Workbook number One. The sixteen test frames were selected to sample the reading vocabulary and skills from Workbook One. The child was shown the test frames and requested to respond by pointing to the correct answer. A child's response was judged correct (+) if the child indicated the correct Rebus answer by pointing to it. The oral response of the child did not affect the scoring. A percent score of the correct responses was computed for each subject. It was felt that a basal level of performance would be established by sampling the reading skills from Workbbok One, therefore, a test of Workbook Two was not included.

Presentation of the Peabody Rebus Reading Program

The Peabody Rebus Reading Program was selected as an appropriate readiness and introductory reading program and was presented during the six-week, 1971 summer session at the University of Tennessee Preschool Program for Hearing-Impaired Children. The teaching techniques outlined in the seventy-two page Teacher's Guide of the PRRP were followed during reading instruction. The Rebus Program utilizes programmed workbooks and therefore minimizes the teacher's role. The teacher's role was mainly to supervise the reading program and to check each child as he progressed through the workbooks. The reader is referred to the Teacher's Guide for specific information concerning the teaching techniques utilized. In general, new rebuses or skills were presented orally by the teacher to the group in association with the three-by-five cards and the teacher's workbook. The children then progressed individually through the appropriate frames in their workbooks. As the children worked individually, the teacher circulated among the four children to check accuracy, provide the microphone for auditory feedback while reading and clarify any difficulties encountered. When the children completed the appropriate frames in the workbook, the group was again assembled and each child read a workbook frame until the day's lesson had been completely read and reviewed orally. All group work and the daily page-by-page review was oral. Reading instruction was presented daily. The reading sessions were approximately thirty to forty-five minutes in length. Twenty-nine reading sessions were presented from June 6, 1971 to July 30, 1971 which corresponds to testing time T-12.

Two factors outside the teaching situation were viewed as very important in determining a child's success in the reading program. The first and most important was consistent daily attendance for all children. There were no scheduled review or tutoring sessions to help a child "catch-up" if he were absent. Due to the programmed nature of the workbooks, a child was at a very great disadvantage if he had been absent. Another factor was that of parent involvement in the reading program. A seventy-five minute, parent education conference was held at the outset of the reading program. All four mothers and one father attended this session. The purpose of this conference was to introduce the reading program, briefly explain the progression of vocabulary and skills in the workbooks and explain in depth the parent role in the reading program. Their role was outlined as twofold: first, to have their child attend the preschool program daily during the six-week summer session and secondly, to review the workbooks daily with their child at home. Notes were written daily at the conclusion of each day's work indicating where review was needed.

Teaching techniques to be used at home during the review were presented, demonstrated, and discussed.

Testing Reading Progress

Since the Rebus Program contains no published test to measure progress, six tests of four consecutive workbook frames were selected to sample the reading skills from Workbook One and Two. The first four tests were the same sixteen frames administered before the introduction of the reading program. Since the children progressed past the half-way mark of Workbook Two, two additional tests of four frames were chosen. The following workbook frames were selected as test frames: frames 89-91, 189-192, 280-283 and 336-339 from Workbook One; and frames 97-100 and 186-189 from Workbook Two. The tests required the child to read aloud twenty-four Rebus test frames and select and read the appropriate answer. Testing was done individually under the same conditions as earlier testing. Testing was recorded on a Wollensak tape recorder. Responses were scored in two ways: phonetic transcription of all phonemic reading errors, and correct (+) or incorrect (-) based on the selection of the appropriate answer to each frame. Responses were phonetically transcribed using the International Phonetic Alphabet to allow comparison of the reading errors with the earlier perceptual test.

Evaluation of the Data

The following percentage scores were computed for the tests administered prior to the introduction of the reading program: (1) the percentage of rebuses known for each child from Workbook One and Two, (2) the percentage of correct responses for the sixteen test frames from Workbook One, (3) the percentage of correct, slightly distorted and incorrect speech sounds on the consonant perception test.

The following percentage scores were computed based on the tests administered during presentation of the reading program: (1) the percentage of correct responses in answering the test frames in Workbook One and Two, (2) the percentage of phonemic errors while reading the test frames in Workbook One and Two, (3) the percentage of phonemic errors that occurred in reading that were also incorrect or slightly distorted on the consonant perception test.

For this Interim Report, only the data that has been analyzed will be discussed. Table 29 displays the scores from the Perception test for subjects S_8, S_9, S_{11}, and S_{14}. The mean for these four subjects for each category is as follows: (1) 54 percent correct, (2) 33 percent incorrect, and (3) 14 percent slightly distorted. A score of 54 percent correct is an excellent score for children who have as severe a hearing impairment as these four children.

Table 30 displays the percent correct of the sixty-eight Rebus symbols for a test administered prior to the reading program. The mean percent correct for the four children was 45 percent. It is interesting that these children had knowledge of almost half of the Rebus symbols before the reading program began, and the program is designed for hearing children.

Table 31 displays the pre- and post-test scores for each child as measured by the Rebus Reading Test. The group mean for the pre-test was 56 percent, whereas it was 83 percent for the post-test. The mean percent of improvement for the group was 27 percent for 29 reading sessions over a 6-weeks period. S_8, S_{11}, and S_{14} improved 31, 37 and 32 percent, respectively. S_9 only

TABLE 29

PHONEMIC PERCEPTION TEST OF 24 ENGLISH CONSONANTS IN THE INITIAL, MEDIAL, AND FINAL POSITION ACCORDING TO PERCENT CORRECT, INCORRECT, AND SLIGHT DISTORTION

	Scoring of the Responses		
SUBJECTS	% CORRECT	% INCORRECT	% SLIGHT DISTORTION
S_{8}(Sa)	55	30	15
S_{9}(Sa)	59	37	4
S_{11}(Sa)	57	40	3
S_{14}(Sa)	44	24	32
MEAN	54	33	14

TABLE 30

REBUS SYMBOL TEST IN PERCENT CORRECT OF 68 REBUS SYMBOLS FROM BOOK ONE AND BOOK TWO

SUBJECTS	% CORRECT
S_{8}(Sa)	51
S_{9}(Sa)	41
S_{11}(Sa)	43
S_{14}(Sa)	43
MEAN	45

TABLE 31

PRE- AND POST- SCORES FOR REBUS READING TEST IN PERCENT CORRECT

	(Percent Correct)		
SUBJECTS	PRE-TEST	POST-TEST	IMPROVEMENT
S_{8}(Sa)	60	91	31
S_{9}(Sa)	60	66	6
S_{11}(Sa)	55	92	37
S_{14}(Sa)	50	82	32
MEAN	56	83	27

improved 6 percent during this period; however, this may be attributed to her poor attendance. She was only able to attend approximately 50 percent of the sessions. These results indicate that the Rebus Reading Program can demonstrate significant improvement in the reading skills of preschool deaf children in a short period of time.

Table 32 displays the phonemic errors on the reading test. The group mean was 32 percent. For these deaf children who are between 6 and 7 years of age, 68 percent of their reading contained no phonemic errors. A normal-hearing child of similar age and training would probably score between 75 to 95 percent.

The second column in Table 32 displays the percent of these errors that were also errors on the perception test. The group mean is 82 percent with a range from 72 to 93 percent. These results demonstrate a high correlation between perceptual errors and phonemic errors in reading. This suggests that children who learn to make maximum use of their residuum of hearing will probably be better readers. These results stress the importance of intensive auditory training to develop auditory perception for preschool deaf children.

TABLE 32

PHONEMIC ERRORS ON THE REBUS READING TEST IN PERCENT CORRECT THAT WERE ALSO ERRORS ON THE PERCEPTION TEST

Subjects	Phonemic Errors in Reading Test in Percent	Percent of Phonemic Reading Errors That Were Also Errors on Perception Test
S_8(Sa)	32	93
S_9(Sa)	29	77
S_{11}(Sa)	24	84
S_{14}(Sa)	42	72
MEAN	32	82

CHAPTER XII
INTEGRATION PROGRAM

On January 1, 1971, state funds were obtained for a proposal submitted by the writer. These state funds allowed three additional teaching positions for our preschool deaf program. Because of the additional staff, we were able to begin an Integration Program at the University of Tennessee Child Development Center which is a short distance from the Preschool Deaf Program.

From January 1 to June 1, 1971, six deaf children, who attended the Preschool Deaf Program in the morning, were also enrolled in the Integration Program which included six normal hearing children. Mrs. Janis Macy Shirley, a graduate student in Child Development, and Mrs. Mary McClanahan Peterson, a teacher in our Preschool Deaf Program, were responsible for integration of the six deaf children. Mrs. Shirley was employed on the newly-acquired state funds and Mrs. Peterson on federal funds. This six month session was during our second fiscal year of the federal grant which included testing time T_{11}. The reader is referred to Table 1 for appropriate dates.

The writer was also able to obtain state funds for the school year September 1, 1971, to June 1, 1972, to continue the Integration Program. Mrs. Shirley is also employed for this school year and supervising the program. For this period, three deaf children are attending the Integration Program.

The following is a report written by Mrs. Shirley for the six month period Janaury 1 to June 1, 1971. Mrs. Shirley obtained measures on the children, and this report also will satisfy the requirements for a master's thesis in the Department of Child Development at the University of Tennessee. For the final report on our federal research project, we will include the results of this year's Integration Program.

THE INTEGRATION OF DEAF CHILDREN INTO A PRESCHOOL PROGRAM FOR NORMAL-HEARING CHILDREN

by Janis Macy Shirley

Introduction

Children with hearing difficulties have complex problems in the area of communication which affect their social and psychological adjustment in a hearing world. It is also important to consider the basic needs and capacities for development which the normal-hearing and hearing-impaired child share.

Hearing-impaired children receiving auditory training for speech development have all the educational needs of normal-hearing children. Attention should also be given to means of insuring a good social adjustment. Auditory training plus experience in a preschool for normal hearing children offer opportunities for the hearing-impaired child to use his speech and to share educational and social experiences with a normal-hearing peer group(15)*

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* The reference numbers in this chapter refer to the specific bibliography identified as "Bibliography on the Integration Program" and located in the Reference section of the Interim Report.

Northcott (17), Fiedler (6), O'Connor and Connor (18), and Johnson (10) agreed that the integration of a hearing-impaired child into a normal-hearing class should be considered only with careful direction by a specialist in speech and hearing including counseling, guidance, and individual therapy work in language skills with the child.

> It is proposed...that this bringing together in a really child-centered school situation the best of this special teaching of communication skills with the best of our present-day knowledge of young children and the methods of teaching appropriate to this knowledge...(would) result in deaf children who are happier, freer and more spontaneous, better adjusted to the world and to themselves (6, p. 6).

Preschool education offers an opportunity to develop skills and experiences adapted to the child's individual needs. Recent preschool programs integrating hearing-impaired children into normal-hearing groups have stressed a variety of experiences with hearing children the same age in a controlled environment as being valuable for the deaf child (2, 9, 16, 17, and 26).

Statement of the Problem

The problem under study was to observe and record the social behavior and interaction of six deaf children integrated into a preschool group of six normal-hearing children during a five week period. The normal-hearing children provided the environment for evaluating the interaction of the six deaf children. Evaluation of social interaction was carried out through a time sampling procedure. Data were collected on two normal-hearing children as well as the six deaf children to provide a basis for comparison and interpretation.

An important aspect of this study was to evaluate the effectiveness of the integration experience for the deaf children in using the speech they had learned in a preschool program for hearing-impaired. The program stressed auditory training and speech development.

The length of the study, five weeks, was limited by the schedule of the preschool program. A period of study extending over a longer time would have been desirable. Since the number of normal-hearing children was limited to six, the opportunity for interaction between normal-hearing and deaf children was somewhat limited.

Definition of Terms

The term "deaf" as used in this study describes children not having sufficient hearing to enable them to acquire speech and language naturally. Special assistance through therapy is required to learn language and speech.

Social interaction and social behavior include a child's verbalization (speech) with peers and teachers, gesturing to peers and teachers, deliberate physical contact made with peers and teachers including positive as well as negative behaviors, and observing peers during parallel play or from a distance. Other behaviors included under social interaction and social behavior were laughing with peers and teachers, and crying. Solitary play or behavior was considered in the category "No Interaction."

Procedures

The deaf children in the study included three boys and three girls whose age range was four years to seven years, three months. The mean age of the six pre-lingual deaf children was six years, one month. The range of the 3-frequency average (500, 1000, and 2000 Hz) for pure-tone testing was 61 to 91 dB in the better ear. The mean was 76 dB. The audiograms of these children may be viewed in Appendices A and B.

Mini Suvag hearing aids were worn by the deaf children the entire day with the exception of three hours of therapy work in aural habilitation each morning, five days a week. The Mini Suvags had been worn by four of the children approximately one year, six months and by two of the children less than one year.

The Preschool Program for Hearing-Impaired which the six deaf children attended utilizes the Verbo-tonal Method (7) which works in the habilitation of pre-lingual deaf children. The first step in the method utilizes multisensory stimulation to develop perception of speech. The overall goal is to develop unaided auditory perception to its maximum. Stimulation with and without amplification is an important aspect of the program. Body movements and rhythmical stimulations are utilized to improve speech production and auditory perception. The children work in both group and individual situations (11).

Three of the children were from lower and upper-lower income families qualifying for financial aid from the Crippled Children's Service. Three children were from middle income families as rated by social workers working with the families through the University of Tennessee Preschool Program for Hearing-Impaired. The six deaf children had attended the Preschool Program for Hearing-Impaired for varying lengths of time ranging from three months to three years, seven months prior to entering the kindergarten Integration Program in the University of Tennessee Nursery School. All the deaf children attended the Integration Program at least one month before the data were collected. The six deaf children attended both the Preschool Program for Hearing-Impaired and the Integration Program during the five week period of observation.

The two normal hearing children, one girl and one boy, were five years, six months and six years old, respectively. The mean age for the two normal-hearing children was five years, nine months. Both were from middle income families. These normal-hearing children had attended the University of Tennessee kindergarten program four months prior to the integration of the six deaf children. Due to limited time for data collection, the normal-hearing children were observed over a period of two weeks. Table 33 summarizes the information concerning all subjects whose social behavior and interaction were studied.

Observational Setting

The normal-hearing children in the Integration Program included three boys and three girls whose age range was five years to six years, two months. The mean age for this group of children was five years, eight months. All were from middle income families.

The staff working in the Integration Program included the supervising teacher, an instructor in the Department of Child Development and Family Relationships; the writer, a graduate assistant in Child Development and Family Relationships; and several undergraduates participating in student

TABLE 33

SUMMARY INFORMATION ON SUBJECTS

Subject Number	Sex	Age (Yrs.-Mos.)	HL Av. Better Ear	Time in Hearing-Impaired Program
HEARING IMPAIRED				
S8(Sa)	F	7-3	93 dB	3 yr. 7 mos.
S9(Sa)	F	6	78 dB	3 yr.
S11(Sa)	M	6-5	91 dB	2 yr. 6 mos.
S14(Sa)	M	6-8	101 dB	2 yr. 7 mos.
S41(Sb)	M	6-4	100 dB	1 yr.
S51(S)	F	4	92+ dB	3 mos.
NORMAL HEARING CHILDREN				
H_1	F	5-6		
H_2	M	6		

teaching and practical experience in the nursery school. Also, a graduate student in Audiology and Speech Pathology spent half time in the Integration Program and half in the Preschool Program for Hearing-Impaired.

The normal-hearing children were prepared prior to the integration of the deaf children through simple discussions of how one hears, what it would be like not to be able to hear, and how one might communicate to a person who could not hear. A hearing aid like the deaf children wore was shown to the children. They discussed how it worked, what it did, and the importance of its care. Each child was encouraged to try listening with the hearing aid. It was explained that the new children were coming to the preschool program. They wore hearing aids and were learning to talk.

The Integration Program was held four days a week, Monday through Thursday. The deaf children arrived at the preschool program at 12:30 p.m. and remained at school until 3:00 p.m. The normal-hearing children arrived at 1:15 p.m. and remained at school until 4:45 p.m. The total time which the deaf and normal-hearing children spent together each day was approximately 1 1/2 hours.

Each subject present was observed, if possible, five minutes each day during the free play period. During free play, the children were allowed to move to any activity they chose. Some of the activities available during the free play period included dramatic play, group-initiated games, creative art activities, block building, and a variety of manipulative materials. The free play time seemed to provide the greatest opportunity for the deaf children to interact with their peers.

To avoid distracting the children, social behavior and interaction were recorded from an observation booth which overlooked the entire playroom. The schedule for observing the deaf children was prepared in advance, and the names were rotated so that each child was observed as equal a number of times as possible in the early, the middle, and the late part of the free play period.

Measuring Device

The deaf children were observed under four categories of social interaction. These included the following: (1) Peer interaction, (2) Adult-child interaction, (3) Observes, and (4) No interaction. Table 34 displays the areas of behavior under each of these main categories.

The observer recording sheet was designed for five minute observations. The minutes were marked off in five second units to record coded behavior. The first observed behavior occurring in the five second interval was recorded. If two or more behaviors occurred simultaneously, the closest behavior on the list of peer interactions (A) was recorded. For example, "verbalizes to deaf child (V_D)" was recorded.

A compact cartridge tape recorder was used as the timing device during the observation and recording of behavior. The five second intervals were reliably recorded and time sequences announced to the observer the exact five second intervals. This eliminated the necessity for the observer to monitor visually a stop watch while recording behavior.

A doctoral candidate in Physical Education, experienced in recording behavior using a time sampling method, served as one observer during the period of establishing reliability of the instrument. The writer was the

TABLE 34
CATEGORIES FOR SOCIAL INTERACTION ANALYSIS

Peer Interaction	(a) Verbalizes (speech) to deaf child (V_D) (b) Verbalizes to normal-hearing child (V_N) (c) Vocalizes to himself (V) (d) Laughs with deaf child (L_D) (e) Laughs with normal-hearing child (L_N) (f) Laughs to himself (L) (g) Cries (L-) (h) Gestures (includes pointing or physically acting out thoughts) to deaf child (G_D) (i) Gestures to normal hearing child (G_N) (j) Positive physical contact (includes putting arms around each other, patting, touching, kissing, poking, etc. - - intentionally done) with deaf child (P_D) (k) Positive physical contact with normal-hearing child (P_N) (l) Negative physical contact (includes hitting, pinching, kicking, slapping, etc. -- intentional) with deaf child (P_D-) (m) Negative physical contact with normal-hearing child (P_N-)
Adult-Child Interaction	(a) Verbalizes to adult (A_V) (b) Gestures to adult (A_G) (c) Physical contact with adult (A_P) (d) Adult verbalizes to child (A)
Observes	Observes--aware of other child(ren); listening, watching; also includes parallel play and smiling at peers (O)
No Interaction	(a) Solitary play -- plays alone, unaware of other child(ren) nearby, fails to respond to situation demands; appears unwilling to engage in the ongoing process of communication (S) (b) Leaves room or visual range of observer (E)

other observer. Observer training included a gradual introduction of each behavior code until both observers became familiar will all the codes. The two observers then observed the same child, usually for two minutes, compared their ratings and discussed differences. The two observers worked together six hours over a three-week period observing four and five year olds in a laboratory nursery school and at the University of Tennessee Day Care Center to establish reliability. Williams' (28) method to establish inter-rater reliability for the instrument was used in this study. The total number of behavior instances (360) was divided into the number of agreements (336) between the two observers. Agreement was counted only when both observers had the same recorded behavior for the same interval. Agreement of 93 per cent was reached on a period of 30 minutes of observation. After reliability was established, the observers collected data on the children at different times.

Results

The social behavior and interaction of six deaf children integrated into a normal-hearing preschool program were observed, and behavior was recorded during a five week period. A time sampling method was used to record 20 categories of interaction and social behavior. The social behavior and interaction of two normal-hearing children attending the preschool were also observed and recorded to provide a basis for interpretation of the observation.

The means of the observed categories were calculated for the six deaf and two normal-hearing children. The number of observations was limited and varied among the subjects due to absentees and time available to collect data during the free play period. Therefore, medians were also calculated for the six deaf and two normal-hearing children to determine the proximity of the mean frequencies of observed behavior to that of the medians. Differences of more than one point for the means and medians appeared in 31 per cent of all categories for all subjects. The greatest differences between means and medians were found in Solitary play (S). One of these was found for N_1, a normal-hearing child, who was observed over a brief period of time. Another large difference was found for $S_{8(Sa)}$, a deaf child, who was absent frequently during the period of observation. Her behavior could have fluctuated when she returned after missing several days at a time. The median was approximately 7 points higher than the mean for N_1 and 10 points higher than the mean for $S_{8(Sa)}$.

The overall mean frequency for each category of the six deaf children was compared with the overall mean frequency for each observed category for the normal-hearing children. These results are plotted on a graph in Figure 11.

In verbalizing to deaf children, an overall mean of 4.67 was observed for deaf children verbalizing to deaf children, and an overall mean of 0.52 was observed for normal-hearing children verbalizing to deaf children. An overall mean of 1.17 was observed for deaf children verbalizing to normal-hearing children, and a mean of 11.88 was observed for normal-hearing children verbalizing to other normal-hearing children. The deaf children were observed vocalizing to themselves more often

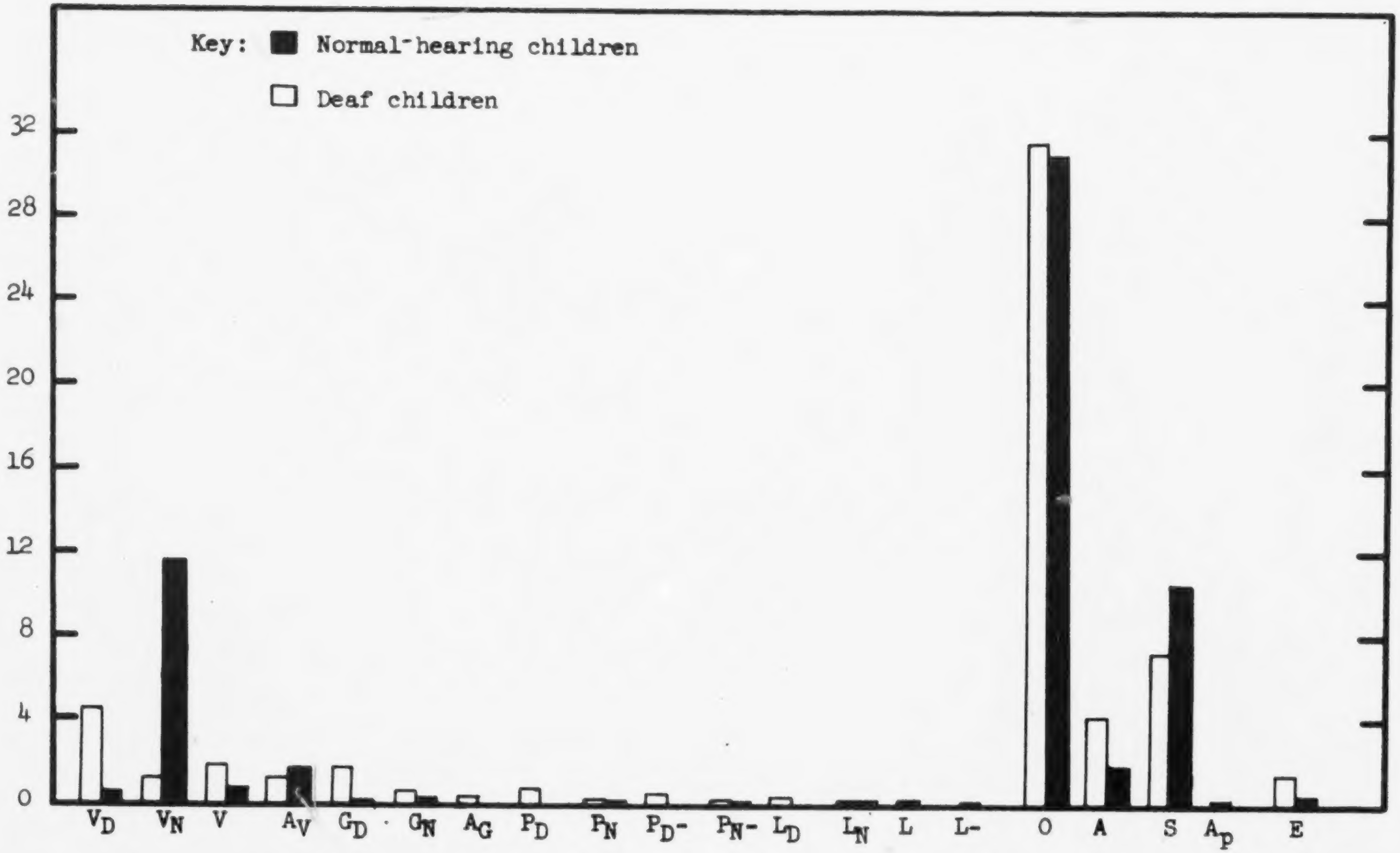

Figure 117. Means of behavioral ratings for normal hearing and deaf children in all categories of social interaction.

(1.99) than normal-hearing children (.72). Also, the deaf children were observed gesturing to each other (1.89) more often than to normal-hearing children (0.29).

Little difference in the positive and negative physical contacts of both the normal-hearing and deaf children was observed. The mean scores of the category "Observes" (O) for the normal-hearing and deaf children showed little difference as well, but behavior in this category occurred with greater frequency for both groups than any other behavior.

The total mean of the category "Adult verbalizes to child" (A) was higher for the deaf children (4.18) than for the normal-hearing children (1.93). The teachers were observed approaching and talking with the deaf children in direction and redirection of behavior more often than with the normal-hearing children. A total mean of 7.33 was observed for deaf children in solitary play while an even higher total mean of 10.41 was observed for the normal-hearing children.

The deaf children were divided into the following three age groups: (1) four years; (2) six years, six years four months, and six years, five months; and (3) six years, eight months and seven years, three months. The normal-hearing children comprise the fourth age group of five years, six months and six years. The means were calculated for each age group under the 20 categories. Figure118 shows the six categories in which there was a difference of one point or more among the overall mean frequencies. Little difference appeared in the mean frequencies of verbalizing to adults, physical contact with other children, gesturing to normal-hearing children or adults, observing, laughing, or crying, and these were therefore omitted from the graph.

The oldest age group had the highest mean frequency in verbalizing to other deaf children (6.90) while the younger deaf children had higher means than the older deaf children in verbalizing to normal-hearing children. The youngest age group received a higher mean in vocalizing to oneself than the two older groups of deaf children.

The two older groups of deaf children had higher means for gesturing to other deaf children than the youngest age group. The mean for the oldest age group was 2.43, the mean for the middle age group was 1.97, and the youngest age group had a mean of 0.53. The youngest age group received the highest mean frequency for adult attention. The two younger age groups of deaf children received higher mean frequencies in solitary behavior (7.71 and 8.85) as did the normal-hearing group (10.41) compared with the oldest group of deaf children (4.87)

The deaf children were divided into groups according to length of attendance in the auditory training program. Group one includes children who had attended three months and one year, group two includes children who had attended two years six months, two years seven months, and three years, and group three included a child who had attended the program three years seven months. The overall mean frequencies were calculated for each of the three groups in each category. Figure 119 shows the overall mean frequencies in the categories revealing a difference of one or more points among the means in each category.

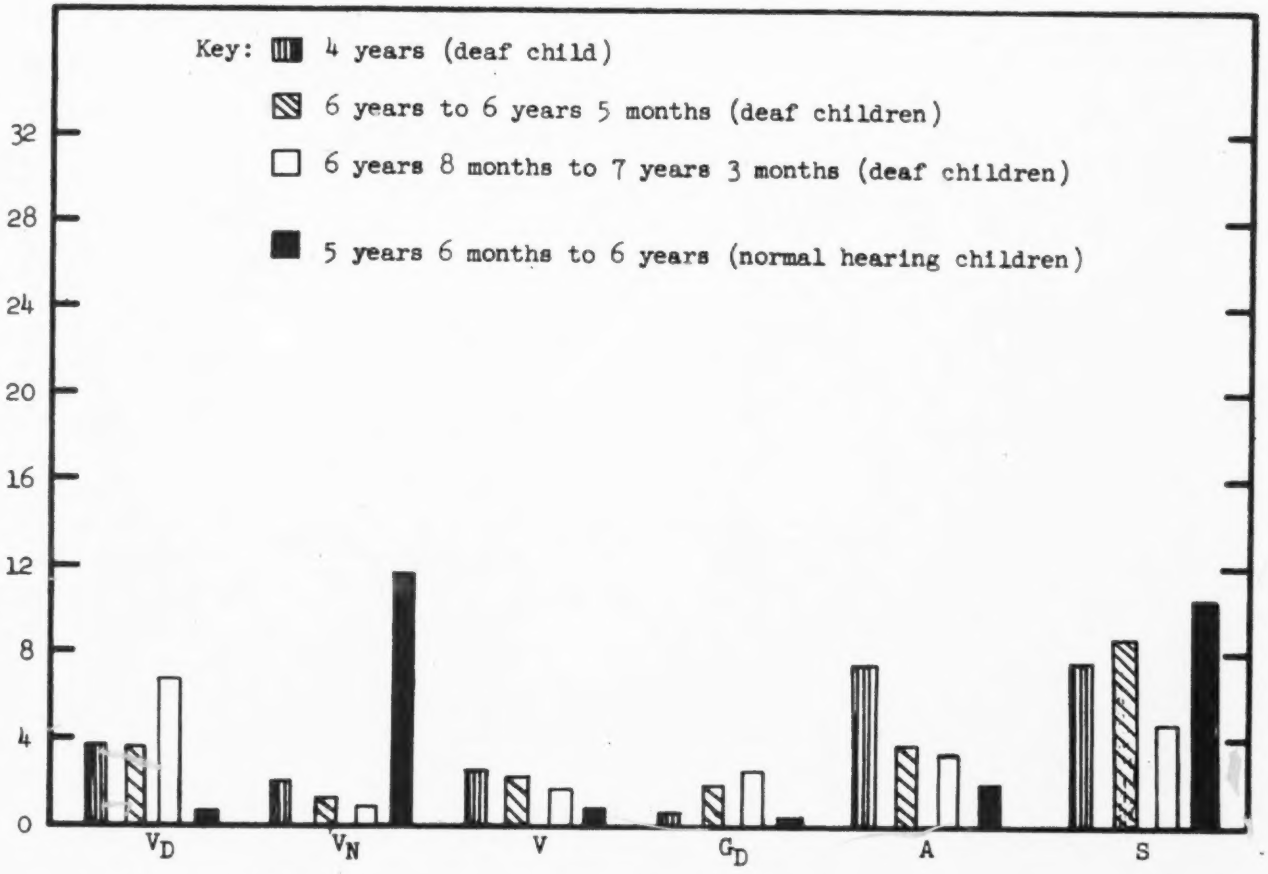

Figure 118. Comparison of means of behavioral ratings for subjects grouped according to age.

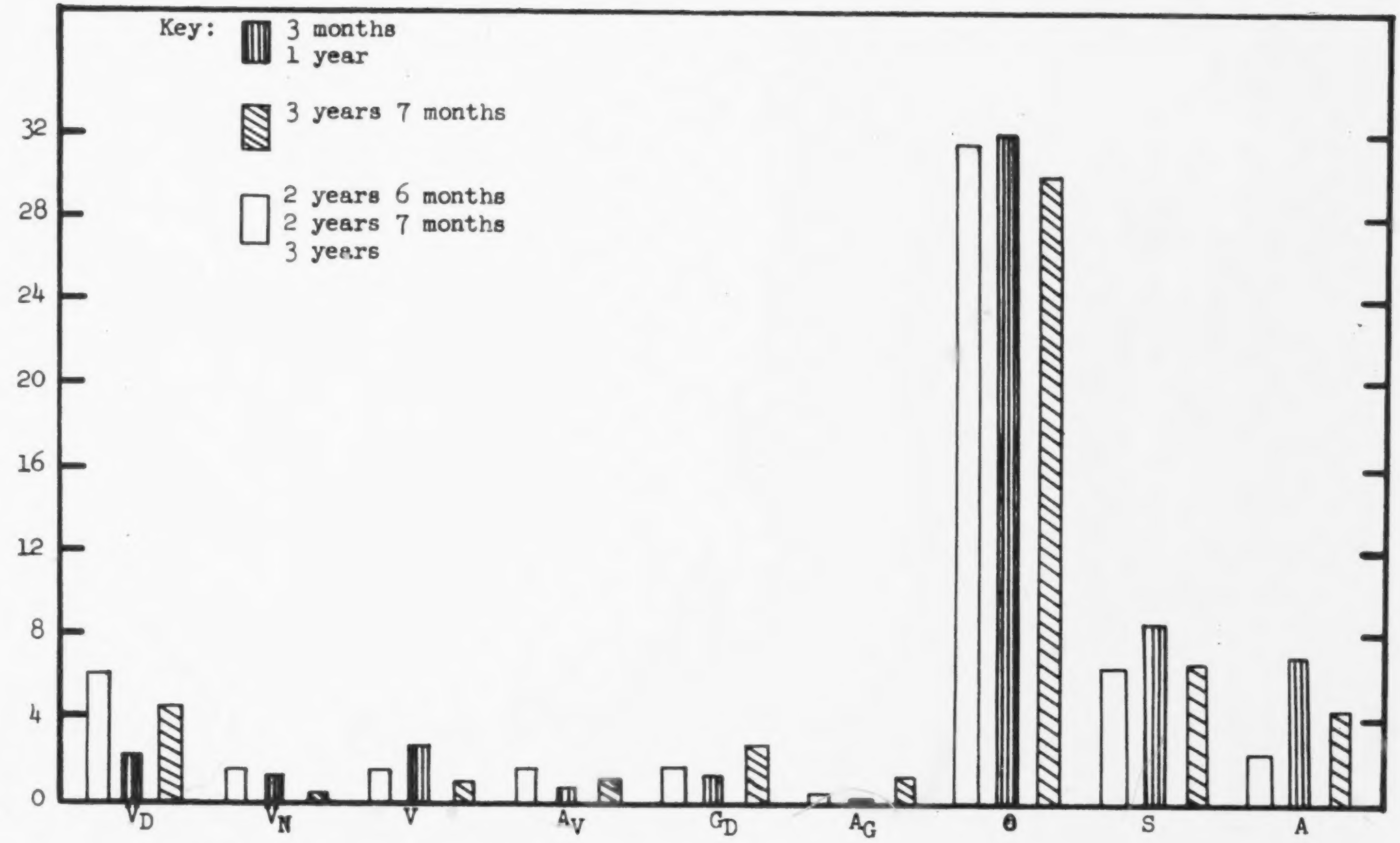

Figure 119.Comparison of means for behavioral ratings of subjects grouped according to length of attendance in auditory training program.

The means for verbalizing to other deaf children were greater for the second and third groups (6.37 and 4.80) which had attended the auditory training program longer than the first group (2.40). The child in the third group who had attended the auditory training program the longest was observed verbalizing to normal-hearing children less often than the first and second groups.

A mean frequency of 2.80 was calculated for vocalizing to oneself for the children in group one. Attending the auditory training program for the longer periods of time, groups two and three were observed vocalizing to themselves less often (1.79 and 1.00). Groups two and three were observed verbalizing to teachers (1.48 and 1.20) more often than group one (0.81).

The child in group three who had attended the auditory training program the longest was observed gesturing to deaf children, normal-hearing children, and adults more often than the other two groups. The first group attending the auditory program the shortest time was observed spending more time in solitary play than groups two and three.

Teachers were observed talking with, directing and redirecting behavior of the children in group one most often (7.10); next, the child in group three (4.40); and least often the children in group two (2.20). Little difference was observed in the means for the other categories.

Figure 120is a bar graph which divides the deaf children into two groups according to hearing loss. Group one includes hearing losses of 61, 66, and 73 dB. Group two includes greater hearing losses of 89, 90, and 91 dB. Means were calculated for both groups in each category.

Group two had a higher overall mean for verbalizing to deaf children than group one, while group one had a higher mean for verbalizing to normal-hearing children than group two. The children in group two were observed gesturing more often than those in group one. The mean for group two in gesturing to deaf children was 2.37 and the mean for group one was 1.41.

The children in group one had a mean of 8.76 for solitary play, and group two had a mean of 5.91 in comparison to a mean of 10.41 for the normal-hearing children. The children in group one were observed receiving more adult attention (5.73) than those in group two (2.68). The children in group two had a higher mean in physical contact with other deaf children than group one. Little difference in means for the other categories appeared.

Discussion

There were a number of factors which possibly influenced the results of this study. The overall mean for a deaf child verbalizing to another deaf child (V_D) was greater than the mean for a deaf child verbalizing to a normal-hearing child (V_N). As might be expected, normal-hearing children verbalized more to other normal-hearing children

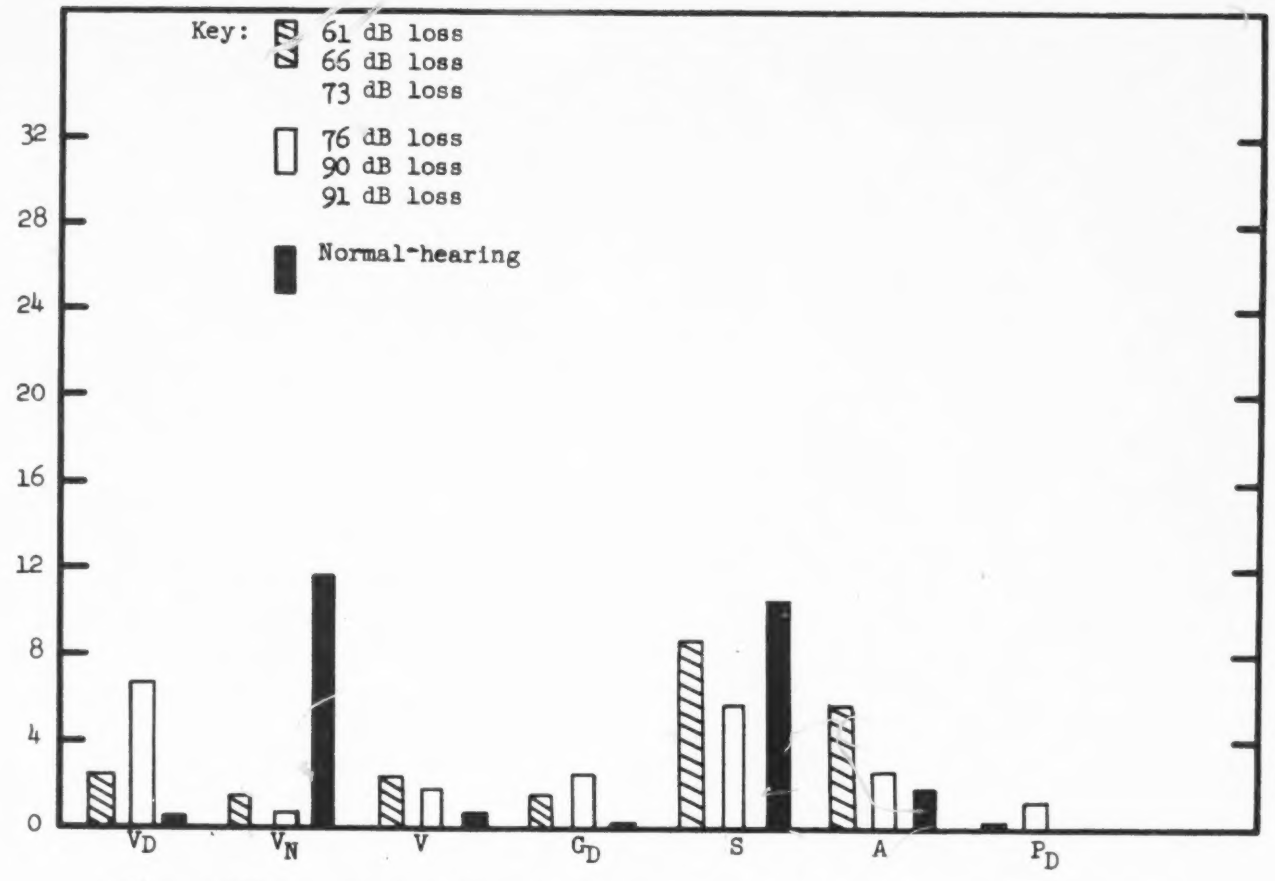

Figure 120. Comparison of means for behavioral ratings for subjects grouped according to degree of hearing loss.

than to deaf children. The deaf children were observed verbalizing to normal-hearing children (1.17) slightly more frequently than normal-hearing children verbalized to deaf children (0.52). This might have been the result of aggressiveness of individual deaf children.

The deaf children were integrated into the preschool program approximately four months after the normal-hearing children had entered school. The deaf children had been together in the auditory training program for a minimum of three months or longer, depending on the individual child; hence, relationships had been established within both groups before they were integrated. The timing for integrating the two groups probably influenced the amount of verbal communication between children. As described in the procedure, the normal hearing children were prepared for the deaf children prior to the integration. Because the integrated group was composed of an equal number of deaf and normal-hearing children, the normal-hearing children seemed somewhat overwhelmed by the different behaviors of the deaf children. A normal-hearing child who spoke to a deaf child often got no response and then left him. Since speech of the deaf children was often difficult to understand, some normal-hearing children seemed threatened when a deaf child verbalized to them, and they moved to another part of the playroom. This behavior decreased during the four months of the program and was changing at the time of data collection.

All but one of the deaf children were older and two of the six were much larger and more active than the normal-hearing children. Two deaf children were considerably more aggressive than the normal-hearing children when they entered the preschool program. In informal observations, the writer and a teacher in the group observed that the normal hearing children seemed to regress to less mature behaviors which the deaf children sometimes used. Such behaviors as pushing, hitting, and pinching to communicate feelings were frequently observed during the initial adjustment to the deaf children.

The data showed little positive or negative physical contact (P_D, P_N, P_D-, and P_N-) between members of both groups which was not expected by the writer. These results may have been due to sampling or changing behavior due to the adjustment of deaf children in the group.

The deaf children gestured more frequently to other deaf children (G_D) than to normal-hearing children or to adults (G_N and A_G). Gesturing did not include any formal sign language. It involved pointing or partially acting out an idea. Gestures were often used with verbalizations. If one occurred first at the beginning of a five second time sampling unit, it was recorded. However, if a verbalization and gesture occurred simultaneously, the verbalizing was recorded. Therefore, gesturing may actually have occurred in greater frequency than the results revealed. The normal-hearing children were also observed using gestures, but not as frequently as the deaf children.

In considering the slightly larger overall mean for vocalizing to self (V) by deaf children as compared with normal-hearing children, it is necessary to consider the type of training the deaf children were receiving. The auditory training program encouraged vocalization regardless of whether or not it was intelligible.

Behavior in the category "Observes" (O) occurred in greater frequency for both groups than in any other area. There was little difference in the overall means for both the deaf and normal-hearing children as well.

Results in this study agreed with Parten's (22) findings that younger children were most often observed in solitary play. Parten also concluded that children who were observed most frequently in solitary play were very shy, independent, or aggressive. Bradway (1) and Myklebust and Burchard's (14) studies showed deaf children approximately one to two years below the Vineland Social Maturity Scale norms for their age.

The frequency of "Solitary play" (S) for normal-hearing children was an unexpected finding. The two normal-hearing children had a greater overall mean in solitary play than the deaf children. This could have been a result of individual differences in children. Subject N_1 was often aggressive or demanding so she played alone at times because she was excluded by the other children. Subject N_2 was somewhat withdrawn throughout the year and was frequently observed in solitary play. Another explanation relates to sampling procedure. The data on the normal-hearing children was collected over a two week period as compared to a five week period for the deaf children.

Among the deaf children subject S51, the youngest child in the group, was frequently observed in solitary play. Another subject, S_9(Sa) began in the integration program being withdrawn and avoided social interaction with anyone. She gradually began interacting with adults, and finally spent more and more time interacting with peers throughout the school term.

Adults (A) were observed spending more time interacting with deaf than with normal-hearing children during free play. The deaf children often needed more help in expressing what they wanted or were trying to say to other children. The teachers often attended to aggressive or withdrawn behavior and spent time helping children become more involved in their activity. Several deaf children were easily distracted from an activity and often needed some adult direction.

The results in comparing three age groups of the deaf children were possibly influenced by the degree of hearing loss, school attendance, and other individual differences. The mean for the two children in the oldest deaf group for verbalizing with other deaf children was greater than for the other age groups. The same oldest group of deaf children had the lowest overall mean for verbalizing to normal-hearing children. This possibly indicates that the oldest group of deaf children was involved in more social interaction with each other.

The two oldest children vocalized to themselves less frequently than the youngest deaf child, possibly indicating more mature speech for the two older children. In regard to gesturing, the oldest children gestured considerably more than the youngest child, again showing more attempts at social interaction.

The adults were observed directing behavior of the youngest deaf child more often than in the other age groups. The oldest age group of deaf children was observed in solitary play less frequently than the other groups. This again indicates these older children spent more time interacting with other children.

In examining results according to length of auditory training, the child in the third group who had attended the auditory training program the longest was frequently absent from the integration program. Therefore, the two other groups were more carefully considered in this discussion. The second group which had attended the auditory training program longer had a higher overall mean in verbalizing to other deaf children than the group with the least training. The length of auditory training appears to be an important factor in the frequency of verbalizations by the deaf children. New words and phrases learned in the training gave the children more words to use in their verbal interaction. A slight decrease in vocalizing to self was observed for the group attending the auditory training program longer.

More solitary behavior was observed for those children who had attended the auditory program the shortest length of time. Adults also spent more time directing the behavior of those children, probably because they seemed to need the most help.

Individual differences and degree of experience seemed most important in examining the overall means in the categories for the children divided into groups according to hearing loss. Children having greater degrees of hearing loss verbalized more to other deaf children than the children in the first group having less hearing loss. Those children having the greater hearing loss had attended the auditory training program longer than two of the three children in the first group. This is another indication that the auditory training program may have influenced the amount of verbalizations made by the deaf children.

There was little observed difference between both groups in verbalizing to normal hearing children. The means for categories of "Gestures to deaf child" and "Positive physical contact with deaf child" were slightly higher for the group having greater hearing loss. The children having less hearing loss also spent more time in solitary play than did those having greater hearing loss. Adult direction was also greater for those having less hearing loss, possibly because these children had attended the integrated program for a short period of time.

The writer noted that deaf children interacted more with others during dramatic play than in other aspects of the preschool program. This is in agreement with Shure's (24) finding that complex social interaction was most often observed in the doll corner. Shure also found more parallel play in the block corner and more solitary behavior in children's use of games. Parten (22) also observed that sand play, constructive work with clay, paper, and paints were characteristically parallel activities. In considering room arrangement, it appears that dividing the room into areas that are relatively small encourages social play, but these areas should be large enough that several children can participate at the same time.

It is the writer's opinion that the deaf children could have gained more from the experience of being a part of a group composed of a higher percentage of normal-hearing children. Although the total number of children must be limited in an integrated group, the writer recommends a ratio of one deaf child to four normal-hearing children. Children in both groups should be of similar size and maturity level. Comminication skills and experience should be considered as well.

Some changes in the preschool program in the present study could have offered a better possibility for more interaction among the deaf and normal-hearing children. By starting all the children at the same time and all attending the program the same length of time each day, previously formed friendships would be at a minimum and a better opportunity to play with other children would probably exist.

The experiences of the children in the present study might have been enhanced through better preparation of the parents of the children for the integration program. Parents would be better able to prepare a child for such a program if prior to the initiation of the program, there was a meeting with parents of both normal-hearing and deaf children to discuss the goals of the program, plans for working with the children, and possible problems which might occur.

It is important for teachers in the program to have an understanding of the special needs of the deaf children. A specialist in the area of special education for deaf or in habilitation of deaf children should be available as a consultant to provide guidance and suggestions for teachers in planning and working with the deaf children.

Further research should include a greater number of subjects controlled for age, experience, social maturity, and communication skills to be carried out over a longer period of time. Assessment of a larger number of normal-hearing children would provide a more representative population for comparison in studying any changes over a period of time in the deaf children's interaction and social behavior. Utilization of a more sophisticated technique for recording the verbalizations of the deaf children such as a radio transmitter system would provide more information for the researcher which could be re-played and analyzed. Recorded speech would make analysis of specific words used that had been learned in therapy sessions possible. The recordings could also be valuable for therapists to listen to for working with the particular speech problems of individual children.

Summary and Conclusion

The purpose of this study was to evaluate through observation, social behavior and interaction of six deaf children who were integrated into a normal-hearing preschool program. Two normal-hearing children attending the integration program were observed to provide a basis for evaluating the extent of interaction of the deaf children.

The mean age of the six deaf children was six years one month, and the mean age for the two normal-hearing children was five years nine months. Hearing losses in the deaf children ranged from 62 to 98 dB with a mean of 81 dB. The deaf children were also attending an auditory training program for the hearing-impaired.

A time sampling procedure developed by the writer was employed to record social behavior and interaction. Inter-observer reliability for the instrument was .93. The overall mean frequencies for each category of the six deaf children were compared with those of the two normal hearing children. It was evident that the deaf children did communicate when placed in an informal free play situation.

For this particular group, the deaf children interacted and verbalized more among other deaf children than with normal-hearing children. Possible reasons are explained. Results were also examined according to age, length of auditory training, and degree of hearing loss. In analysis according to age, results were as anticipated with older deaf children verbalizing more to other deaf children. Deaf children attending the auditory training program for a longer period of time verbalized more to other deaf children regardless of hearing loss.

Further research is needed utilizing larger numbers of children, and observations covering a longer period of time. More sophisticated recording equipment would provide information conerning the amount and quality of speech being used by the children. Suggestions based on this study are made for integrating preschool children into groups of normal-hearing children.

CHAPTER XIII

SUMMARY

It is difficult to summarize the content of this Interim Report without overlooking some important information. As a result, this summary should only be viewed as attempting to highlight some points within each chapter.

Chapter I identified the testing times prior to and during this research grant so that the reader would have a perspective of the measures that were obtained. It also included the rationale of this study.

Chapter II described the experimental procedure with specific information on the subjects, procedures, and comparison between groups.

In Chapter III, the 1-9 scale is described and offered as an indicator of the intelligibility of the speech patterns. Comparisons are made between the Suvag and Warren groups. Although not statistically significant, the Suvag children demonstrated a greater rate of improvement over the testing times of this report. If the Suvag group continues to improve at this rate, it would indicate that low-frequency amplification is more effective in a preschool habilitation program.

Chapter IV includes two related research projects on the rate of vocalization. Then, some measures are described on the rate and duration of vocalizations as measured on our children. In one analysis, the Suvag children had a significantly higher rate. Also included are measurements on rate and duration and comparison between the children.

Chapter V deals specifically with the procedure and some data for measuring the fundamental frequency. Comparisons are made in the mean fundamental frequencies and associated factors such as hearing level. Changes in both mean fundamental frequency and the range of the intonational patterns are discussed for some subjects.

Chapter VI describes conventional and Verbo-tonal audiometry as administered to our preschool children. Comparisons are made between these two different types of audiograms. Hearing aid usage for both the Mini Suvag and the Zenith Vocalizer II is discussed.

In Chapter VII, our new rehabilitative program for children and adults is described. Examples are presented that demonstrate noticeable improvements in speech discrimination scores. These improvements in the rehabilitation program can be demonstrated within months, whereas such improvements are only detectable after years of intensive therapy with preschool deaf children.

Chapter VIII presents electrical and acoustical responses on the auditory training units and the hearing aids. Specifications of each unit are included. Chapter IX describes electronic instrumentation that has been designed for quantification of the speech patterns.

A related research section is presented in Chapter X which includes convention papers and theses.

Chapter XI describes an experimental reading program that was conducted for a six-week summer session. It demonstrates the relationship between auditory perception and the phonemic reading errors of these deaf children.

The reading program of these children in a short period of time is quite impressive when one considers the low reading level of most deaf children.

In Chapter XII, an Integration Program is described where six of our deaf children also attend a preschool program for normal-hearing children Measurements of the interactions of these children are described This chapter should allow the reader to gain some perspective on how these deaf children may function in a normal-hearing society

The last sections of this report include references and the Appendices. This includes information that was too cumberson for the text.

In reading this report, the reader should consider these results as an Interim Report, and no final conclusions on this project should be formulated until the Final Report has been submitted and approved

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2. November, 1969
3. February, 1970
4. May, 1970
5. August, 1970
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7. February, 1971
8. May, 1971
9. August, 1971
10. November, 1971
11. February, 1972

APPENDICES

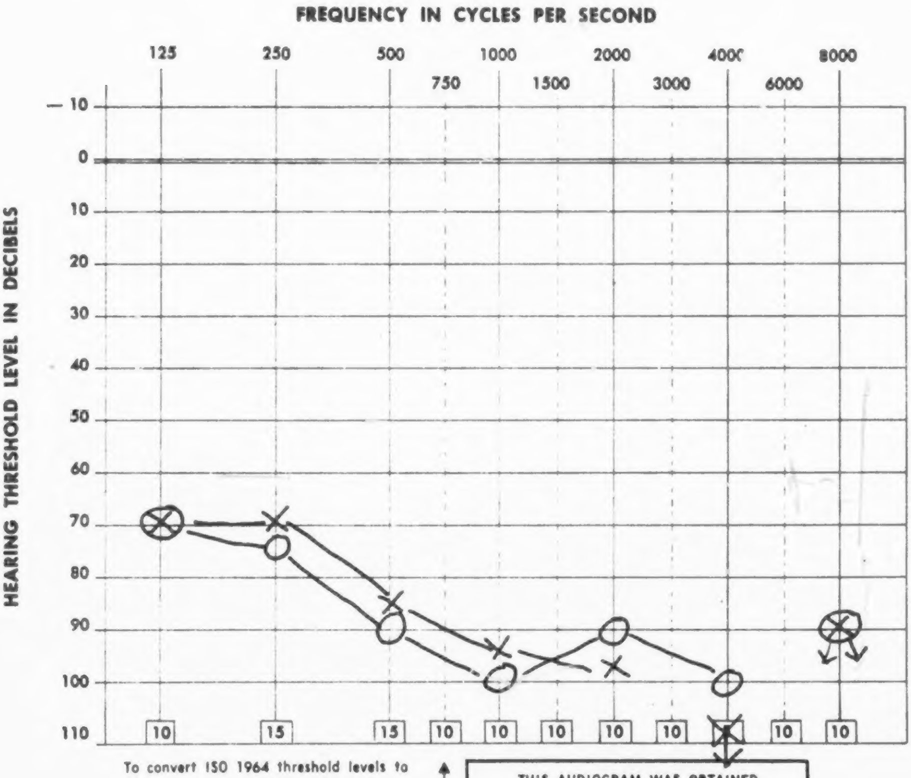
APPENDIX A-1

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name T. Z.: subject 8 (SA) Date of Evaluation 6-23-71

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt. 93 dB Lt. 91 dB

2F AIR Rt. 90 dB Lt. 90 dB

125+250 Rt. 73dB Lt. 72dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt.______dB Lt.______dB

FIELD:______dB

(ALL LEVELS RE NORMAL SRT)

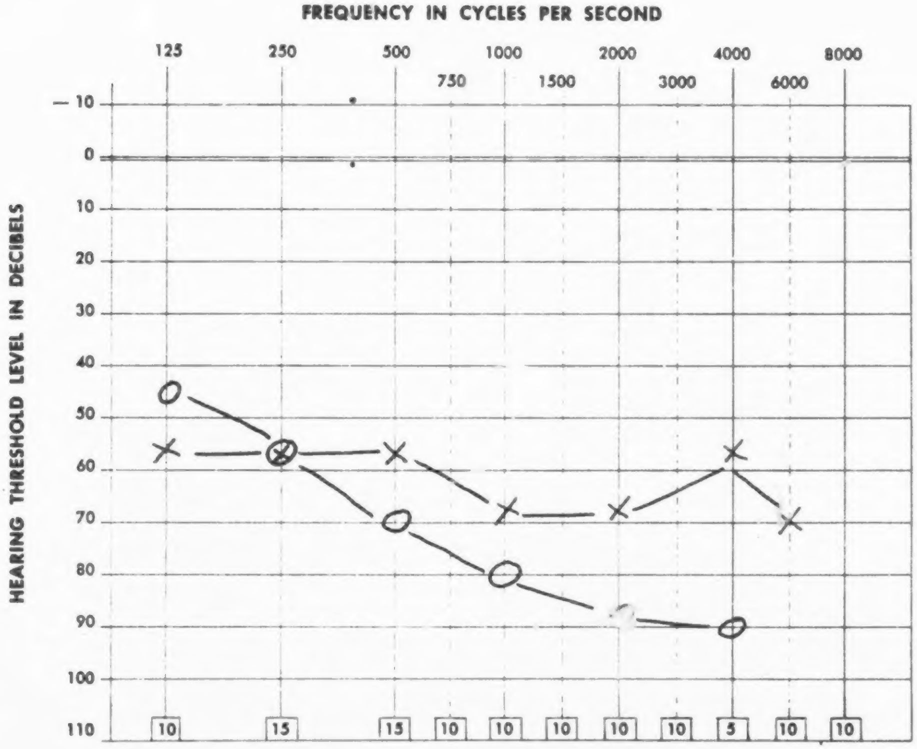
APPENDIX A-2

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name K.C.; subject 9 (S_A) Date of Evaluation 2-23-71

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt 78 dB Lt 61 dB

2F AIR Rt 75 dB Lt 60 dB

125 & 250 RT 50 dB LT 55 dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt ______ dB Lt ______ dB

FIELD: ______ dB

(ALL LEVELS RE NORMAL SRT)

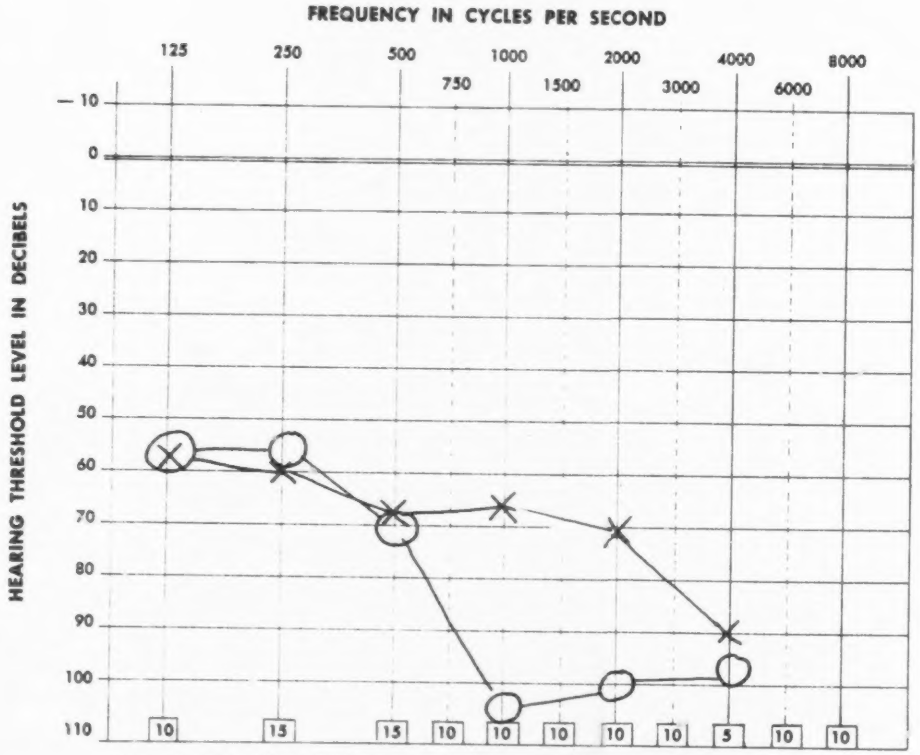
APPENDIX A-3

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name K.B.; subject 11 (SA) Date of Evaluation 4-20-71

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt. 91 dB Lt. 66 dB

2F AIR Rt. 85 dB Lt. 65 dB

125+250 RT 55 dB LT 52 dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt. _____ dB Lt. _____ dB

FIELD: _____ dB

(ALL LEVELS RE NORMAL SRT)

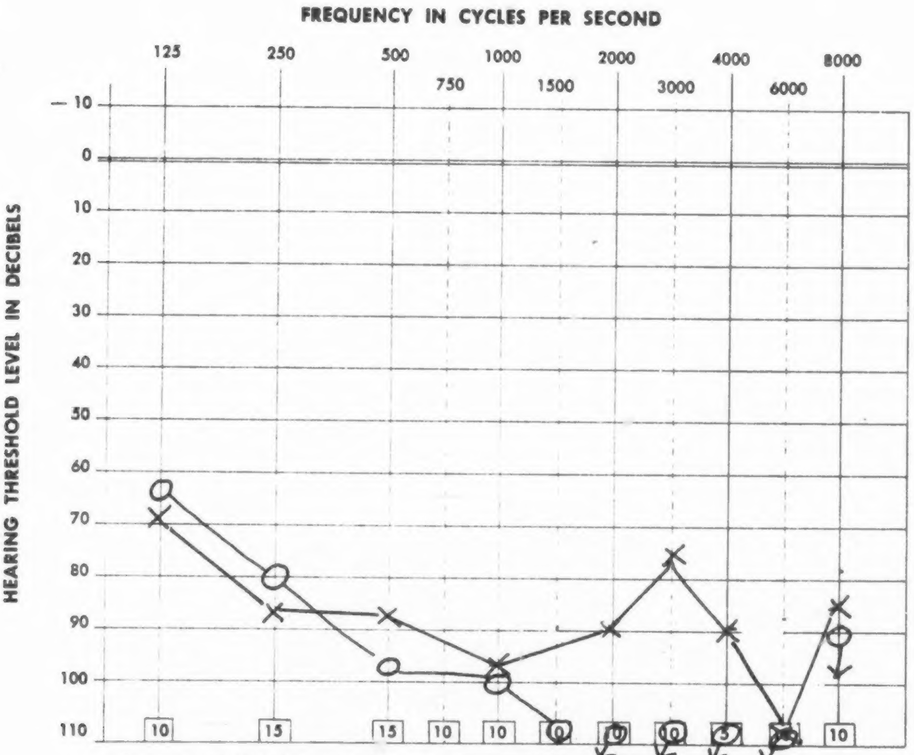
APPENDIX A-4

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name D.D.; subject 14 (SA) Date of Evaluation 8-28-71

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt 101 dB Lt 90 dB
2F AIR Rt 97 dB Lt 87 dB
125+250 RT 72 dB LT 77dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt ___ dB Lt ___ dB

FIELD: ___ dB

(ALL LEVELS RE NORMAL SRT)

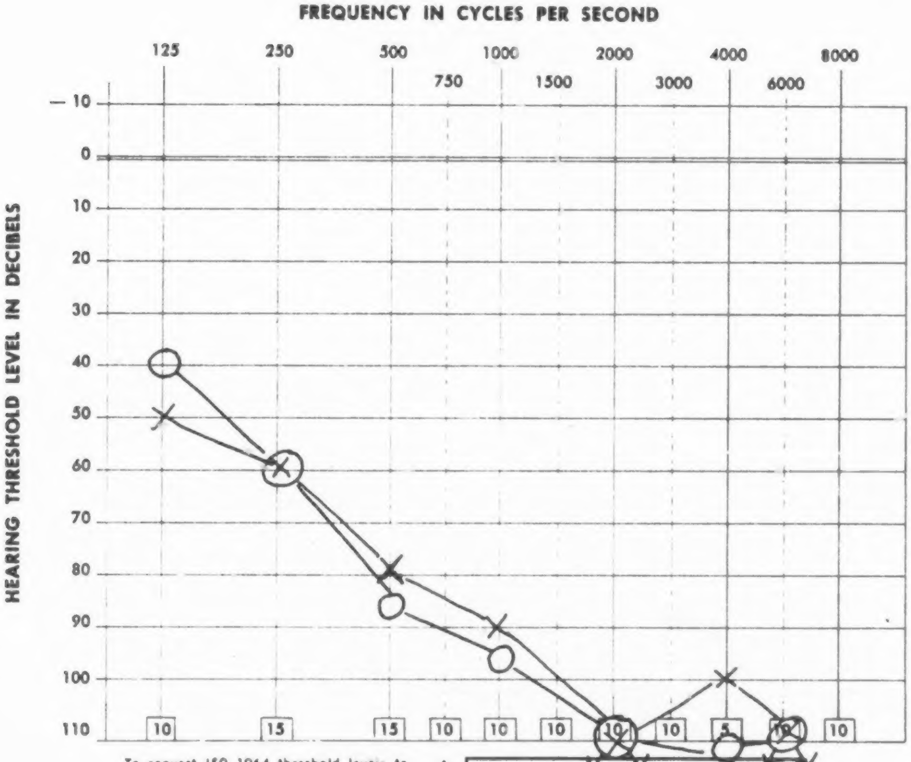
APPENDIX A-5

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name P. R.; subject 15 (SA) Date of Evaluation 7-13-70

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED
AND PLOTTED ON BASIS OF
ISO 1964 ☒ ASA 1951 ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt 96+ dB Lt 93+ dB

2F AIR Rt 90 dB Lt 85 dB

125+250 RT 50 dB LT 55 dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt ______ dB Lt ______ dB

FIELD: ______ dB

(ALL LEVELS RE NORMAL SRT)

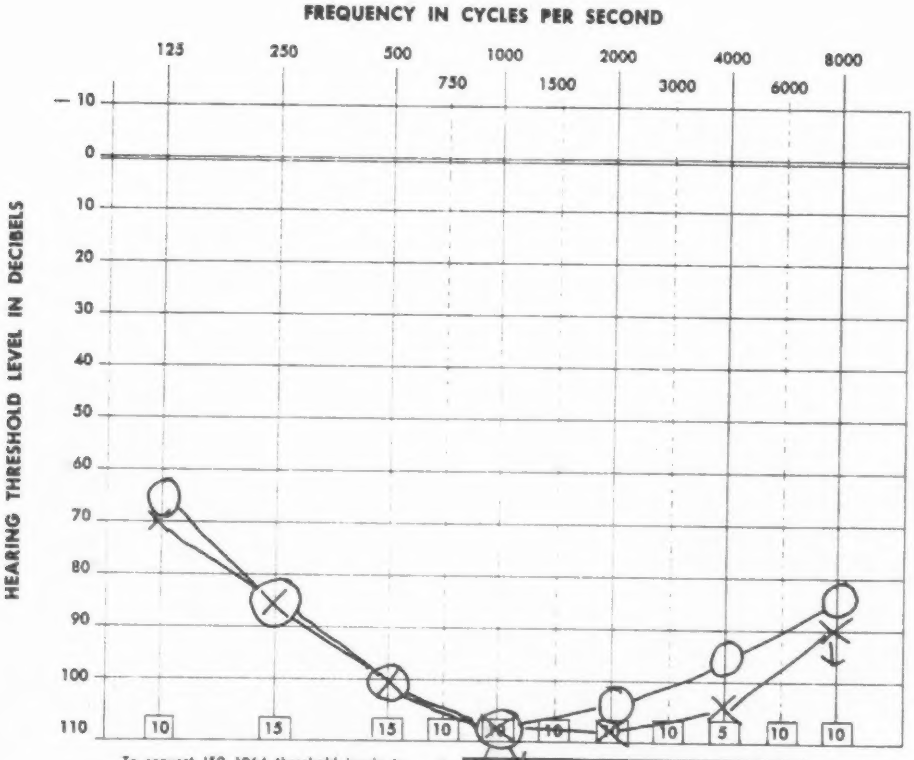
APPENDIX A-6

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name T. E.; subject 16 (S_A) Date of Evaluation 2-23-71

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt 105+ dB Lt 106+ dB

2F AIR Rt 102 dB Lt 105 dB

125+250 RT: 75 dB LT 77 dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt________dB Lt________dB

FIELD:________dB

(ALL LEVELS RE NORMAL SRT)

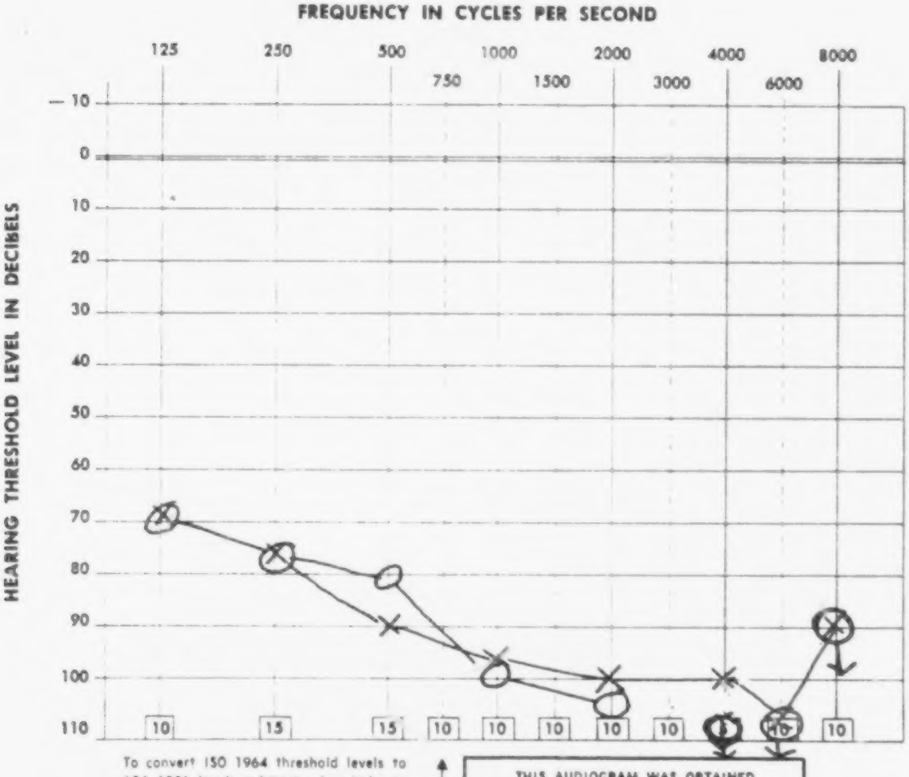
APPENDIX A-7

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name M. P.; subject 17 (S$_A$) Date of Evaluation 4-27-71

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED
AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt 97 dB Lt 95 dB

2F AIR Rt 90 dB Lt 92 dB

125+250 RT 73 dB LT 73 dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt ______ dB Lt ______ dB

FIELD: ______ dB

(ALL LEVELS RE NORMAL SRT)

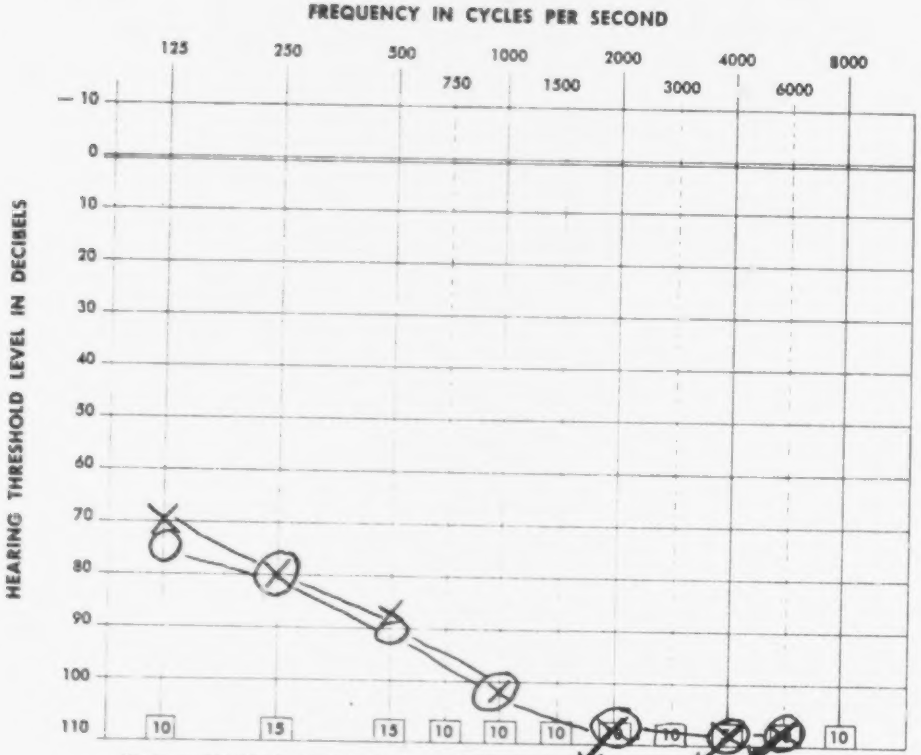
APPENDIX A-8

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name K.F. ; subject 19 (SA) Date of Evaluation 4-3-70

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED
AND PLOTTED ON BASIS OF
ISO 1964 ☐ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt. 100 dB Lt. 97 dB

2F AIR Rt. 85 dB Lt. 82 dB

125 & 250 RT 77 dB LT 75 dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt. ______ dB Lt. ______ dB

FIELD: ______ dB

(ALL LEVELS RE NORMAL SRT)

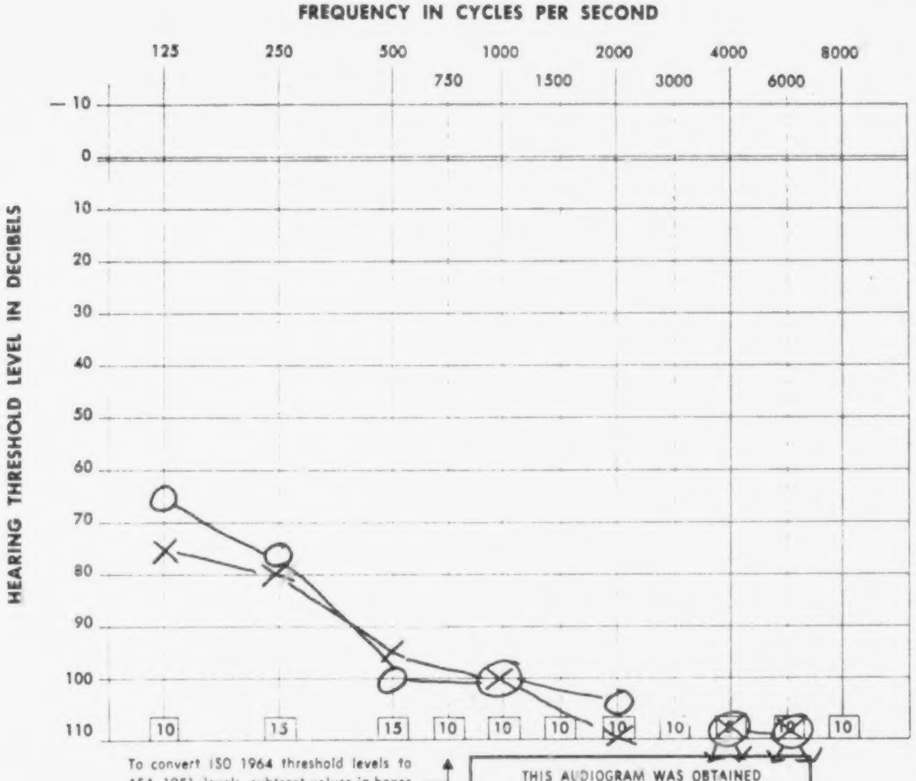
APPENDIX A-9

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name S L.; subject 20 (SA) Date of Evaluation 6·20·70

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED
AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt. 101 dB Lt. 100 dB
2F AIR Rt. 100 dB Lt. 97 dB
125+250 RT 70 dB LT 77 dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE - VOICE SPONDEES OTHER

Rt.________dB Lt.________dB

FIELD:________dB

(ALL LEVELS RE NORMAL SRT)

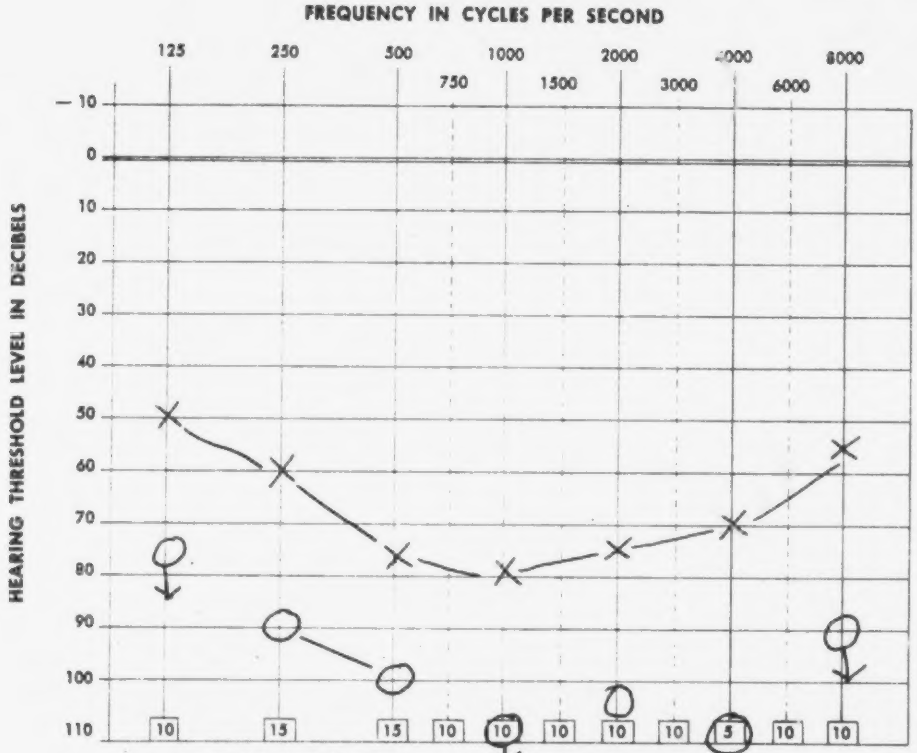
APPENDIX B-1

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name P. D ; subject 22 (SB) Date of Evaluation 1-12-71

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes ↑
To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED
AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt 105+ dB Lt 76 dB

2F AIR Rt 102 dB Lt 75 dB

125-250 RT 82+dB LT 55 dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt _____ dB Lt _____ dB

FIELD: _____ dB

(ALL LEVELS RE NORMAL SRT)

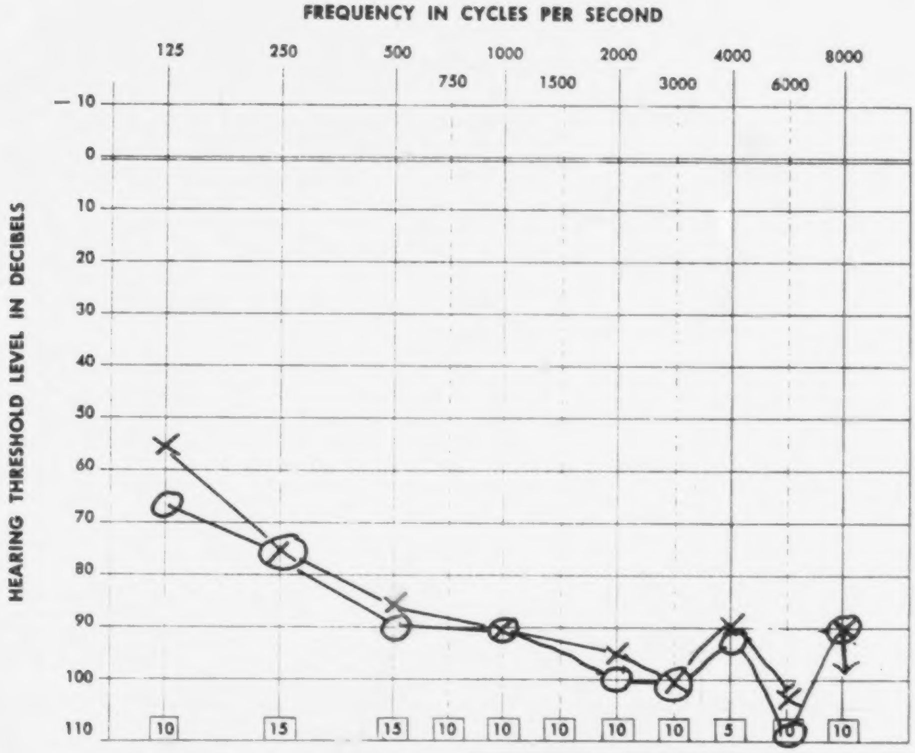
APPENDIX B-2

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name C.S.; subject 25 (s[redacted]) Date of Evaluation 7-29-71

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt 93 dB Lt 90 dB

2F AIR Rt 90 dB Lt 88 dB

1254280 RT 70 dB LT 65 dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE - VOICE SPONDEES OTHER

Rt _____ dB Lt _____ dB

FIELD _____ dB

(ALL LEVELS RE NORMAL SRT)

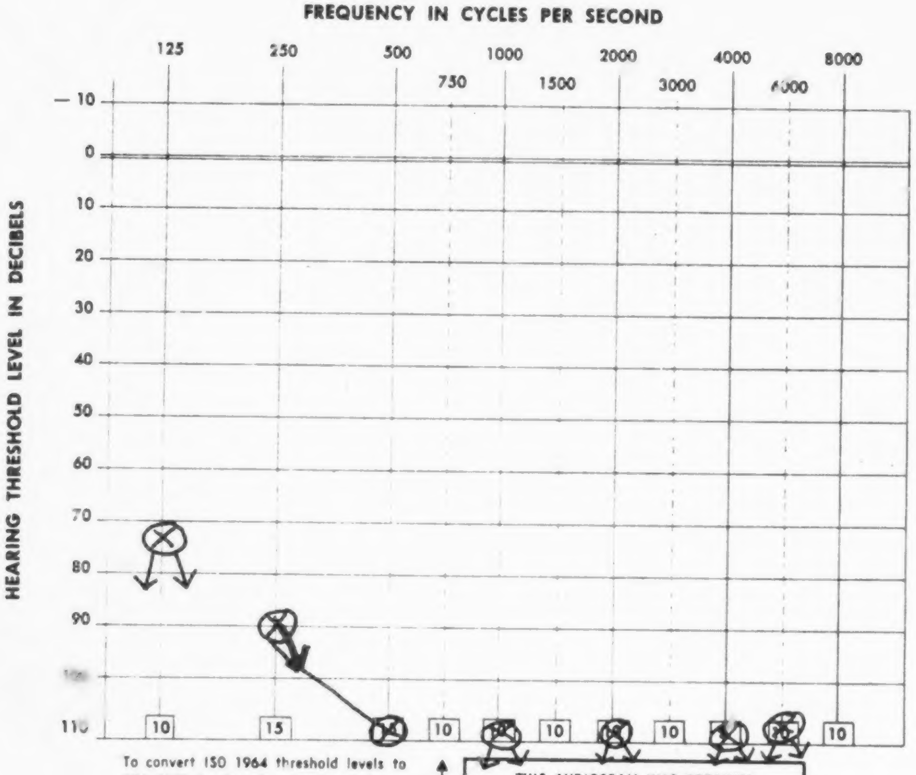
APPENDIX B-3

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name T. K.; subject 27 (S_B) Date of Evaluation 1-15-70

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt 110+ dB Lt 110+ dB

2F AIR Rt 110 dB Lt 110+ dB

125+250 Rt 82+ dB LT 82+ dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt ______ dB Lt ______ dB

FIELD: ______ dB

(ALL LEVELS RE NORMAL SRT)

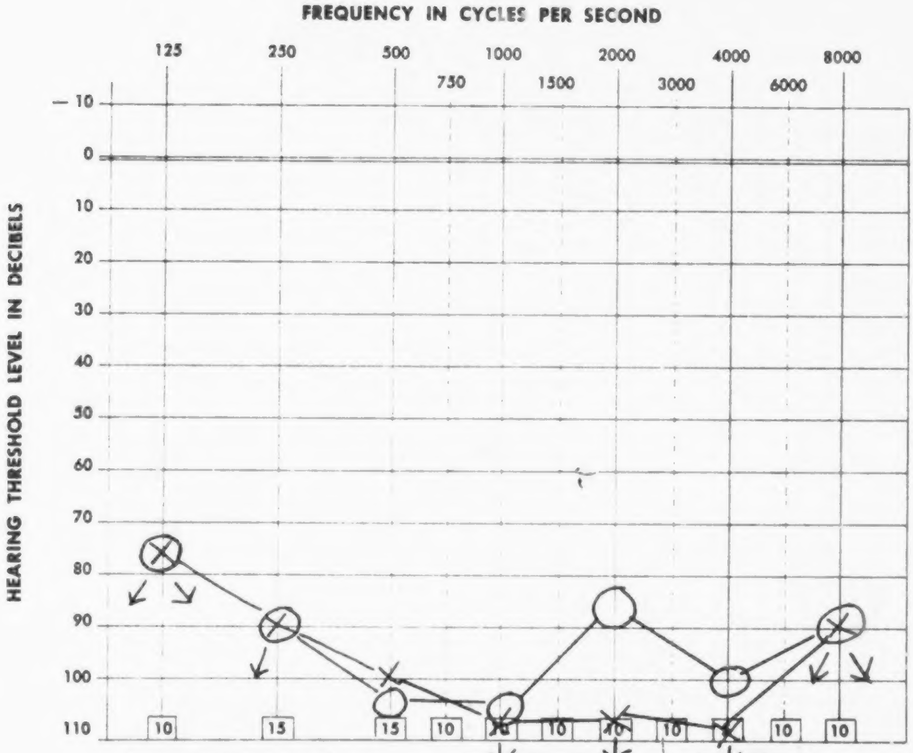
APPENDIX B-4

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name H.S.; subject 28 (Sn) Date of Evaluation 4-20-71

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt 98 dB Lt 106+ dB
2F AIR Rt 95 dB Lt 105+ dB
125+250 RT 82+ dB LT 82+ dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt _____ dB Lt _____ dB

FIELD: _____ dB

(ALL LEVELS RE NORMAL SRT)

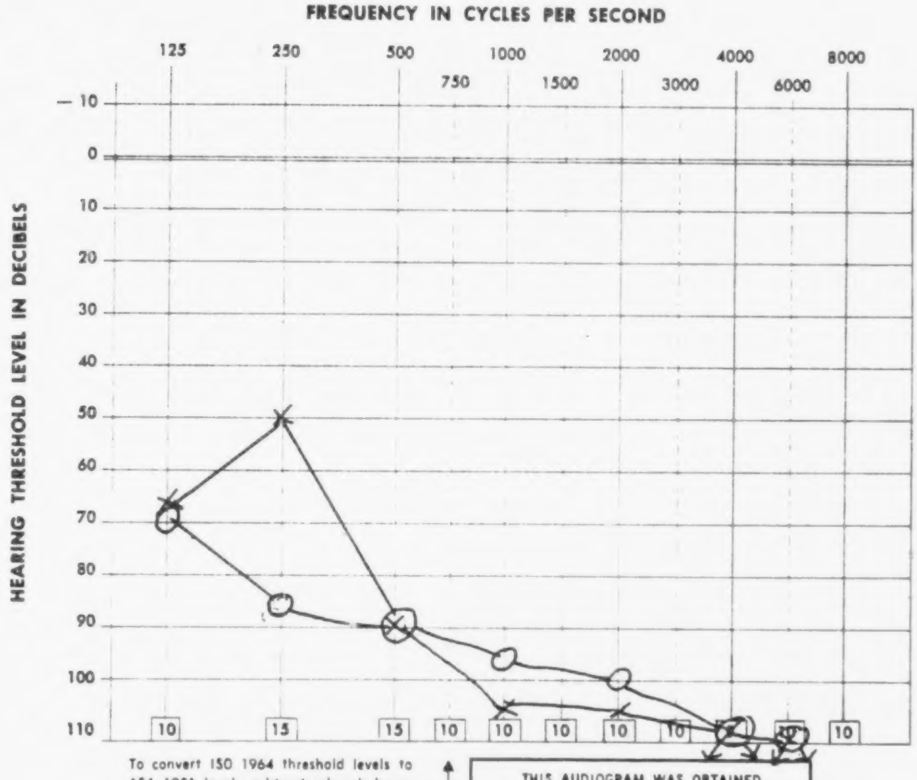
APPENDIX B-5

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name J.S. ; subject 29 (S_3) Date of Evaluation 6-22-70

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt 95 dB Lt 100 dB

2F AIR Rt 92 dB Lt 97 dB

125+250 Rt 77 dB Lt 52 dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt _____ dB Lt _____ dB

FIELD: _____ dB

(ALL LEVELS RE NORMAL SRT)

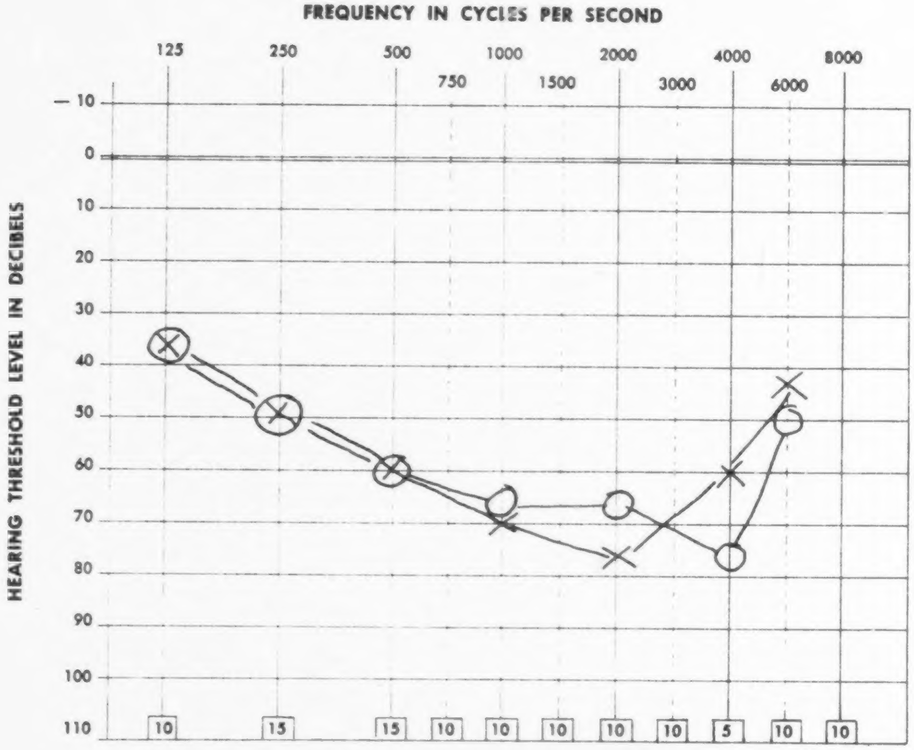
APPENDIX B-6

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name D.P. ; subject 39 (SB) Date of Evaluation 3-5-70

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt. 63 dB Lt. 68 dB

2F AIR: Rt. 62 dB Lt. 65 dB

125+250 Rt. 42 dB Lt. 42 dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE - VOICE SPONDEES OTHER

Rt. ______ dB Lt. ______ dB

FIELD: ______ dB

(ALL LEVELS RE NORMAL SRT)

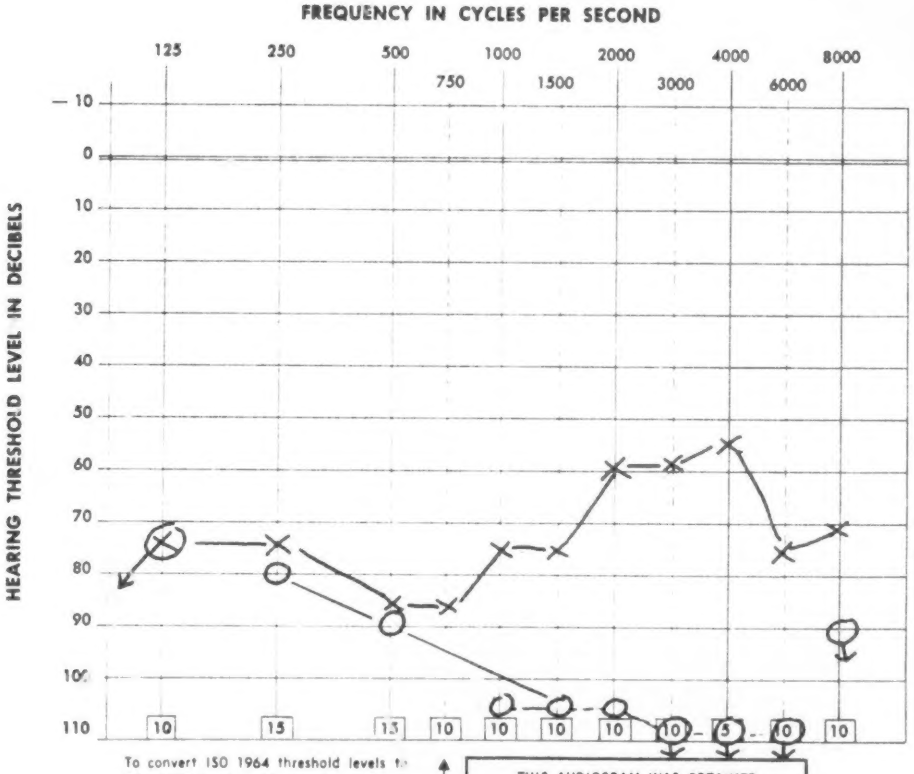
APPENDIX B-7

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name T. S.; subject 41 (s_B) Date of Evaluation 2-28-71

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt 100 dB Lt 73 dB

2F AIR: Rt 98 dB Lt 68 dB

125 + 250 RT 77+ dB LT 75 dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt ______ dB Lt ______ dB

FIELD: ______ dB

(ALL LEVELS RE NORMAL SRT)

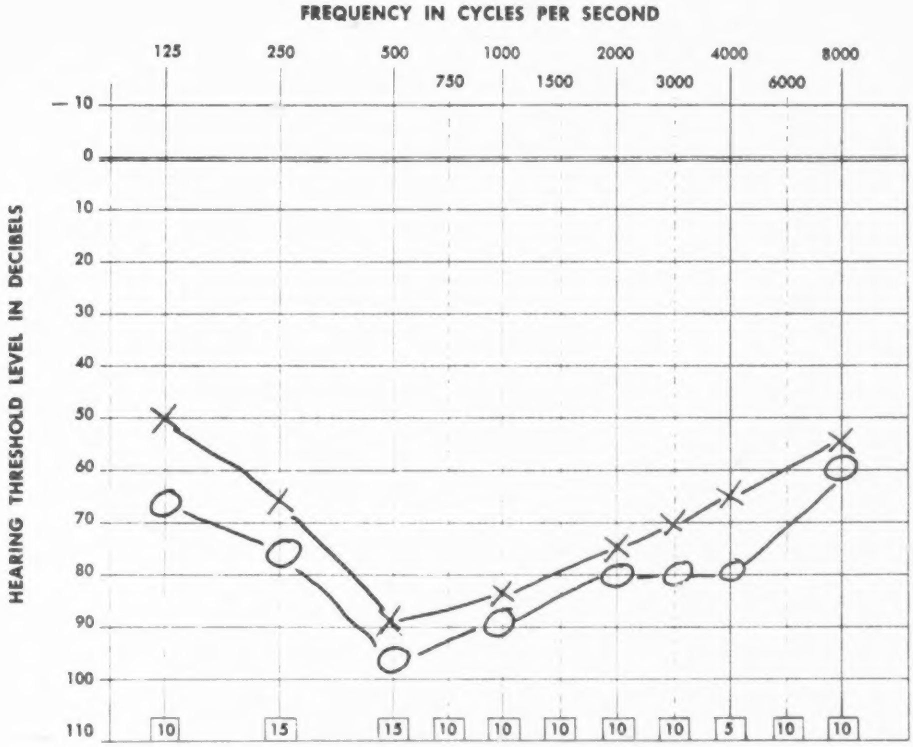
APPENDIX B-8

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name J. P ; subject 42 (S$_B$) Date of Evaluation 10-11-71

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt 88 dB Lt 83 dB

2F AIR Rt 85 dB Lt 80 dB

125+250 RT. 70 dB Lt. 57dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE - VOICE SPONDEES OTHER

Rt______dB Lt______dB

FIELD:______dB

(ALL LEVELS RE NORMAL SRT)

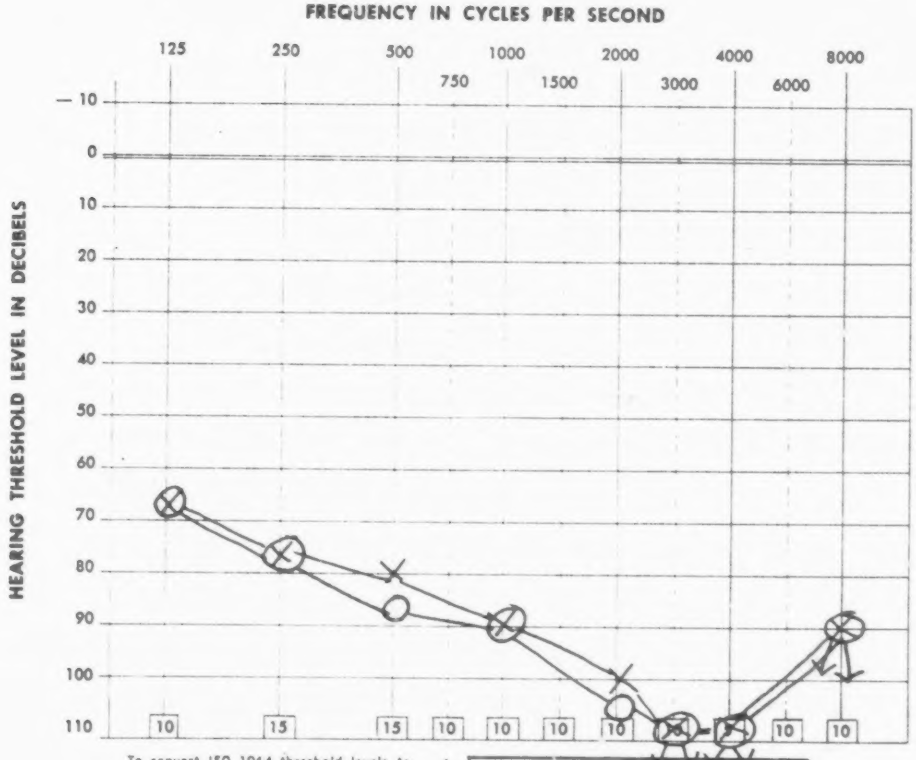
APPENDIX C-1

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name M.W.; subject 24 (w) Date of Evaluation 10-4-71

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt. 93 dB Lt. 90 dB

2F AIR Rt. 87 dB Lt. 85 dB

125+250 RT. 70 dB LT. 70 dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt.______dB Lt.______dB

FIELD:______dB

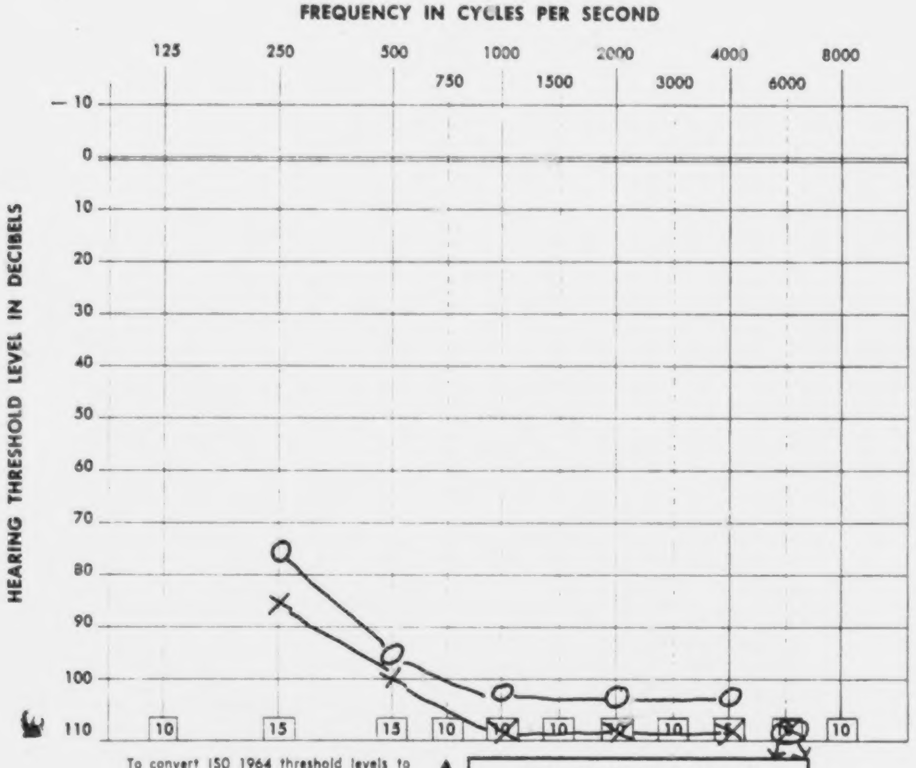
(ALL LEVELS RE NORMAL SRT)

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name D.C.; subject 26 (w) Date of Evaluation 7-19-70

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED
AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt. 101 dB Lt. 106 dB

2F AIR Rt. 100 dB Lt. 105 dB

125-250 RT ____ dB LT ____ dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt.________dB Lt.________dB

FIELD:________dB

(ALL LEVELS RE NORMAL SRT)

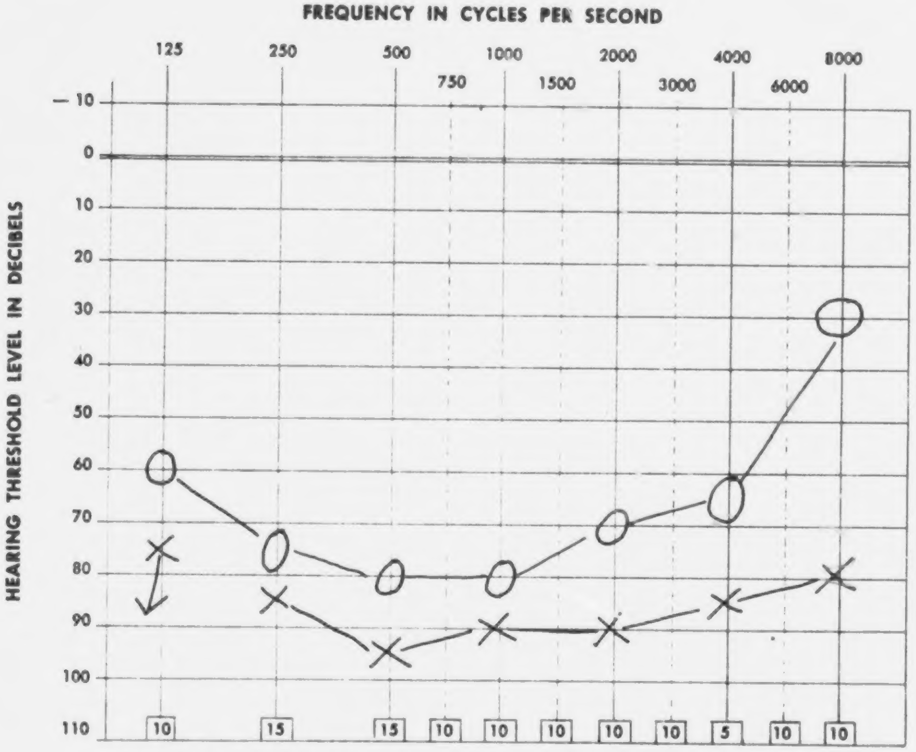
APPENDIX C-3

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name D.B.; subject 31 (w) Date of Evaluation 5-4-71

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, [illegible], 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED AND PLOTTED ON BASIS OF
ISO 1964 ☒ ASA 1951 ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt 76 dB Lt 91 dB

2F AIR. Rt 75 dB Lt 90 dB

125+250 RT 67 dB LT 80+dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt______dB Lt______dB

FIELD:______dB

(ALL LEVELS RE NORMAL SRT)

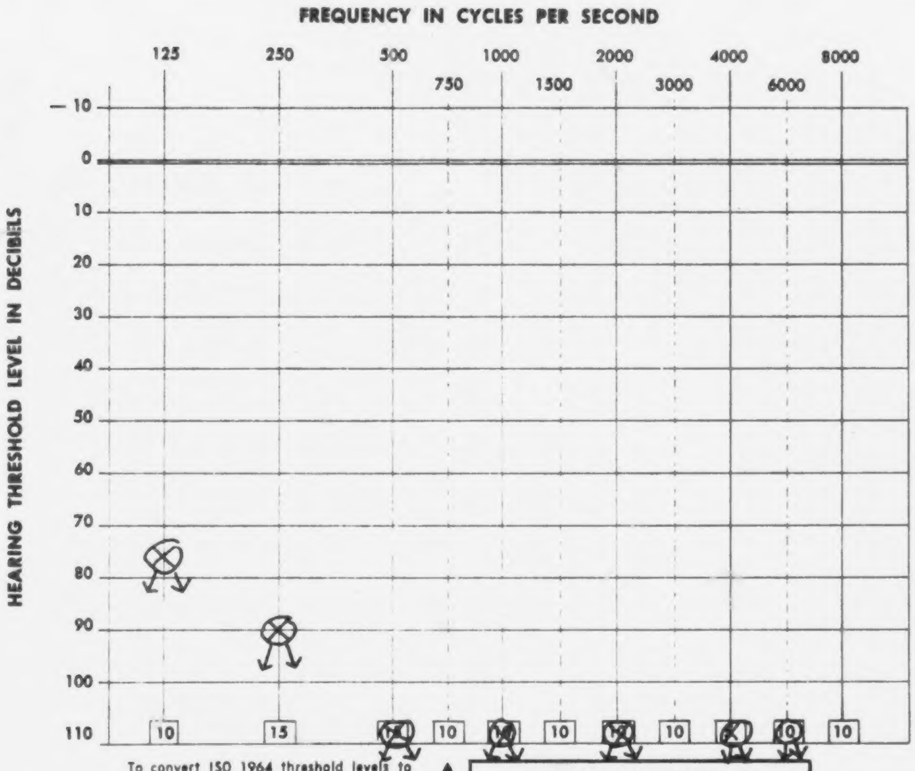
APPENDIX C-4

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name S.D. ; subject 33 (w) Date of Evaluation 4-29-70

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt 110+ dB Lt 110+ dB

2F AIR Rt 110+ dB Lt 110+ dB

125+250 RT 82+dB LT 82+dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt ______ dB Lt ______ dB

FIELD: ______ dB

(ALL LEVELS RE NORMAL SRT)

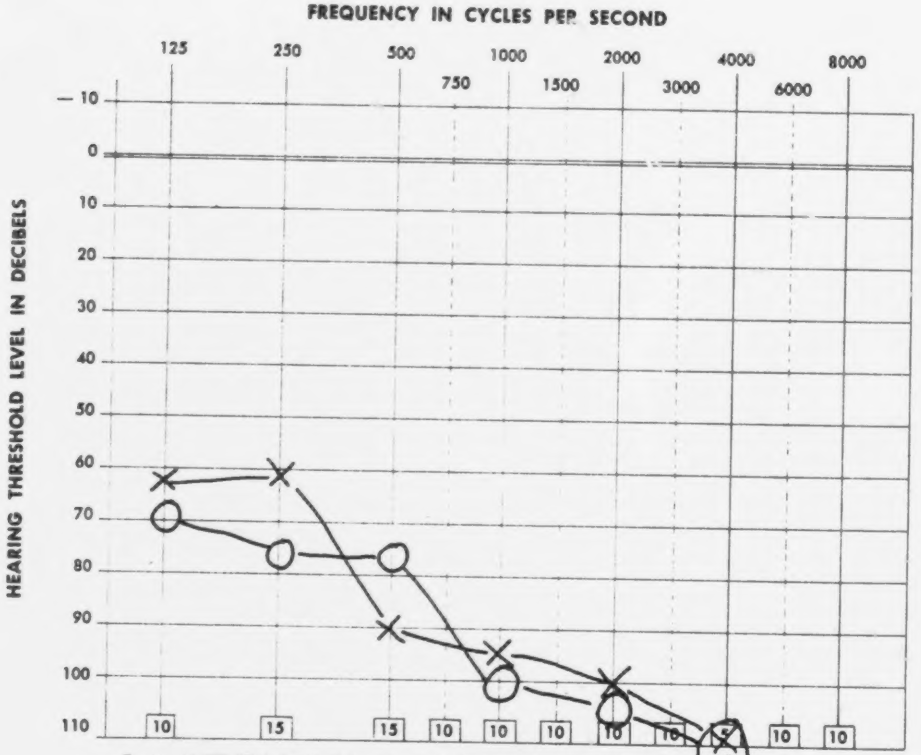
APPENDIX C-5

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name S. McM.; subject 35 (w) Date of Evaluation 2-2-71

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes ↑ To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt 93 dB Lt 95 dB

2F AIR Rt 87 dB Lt 92 dB

125 & 250 RT 72 dB LT 62 dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt________dB Lt________dB

FIELD:________dB

(ALL LEVELS RE NORMAL SRT)

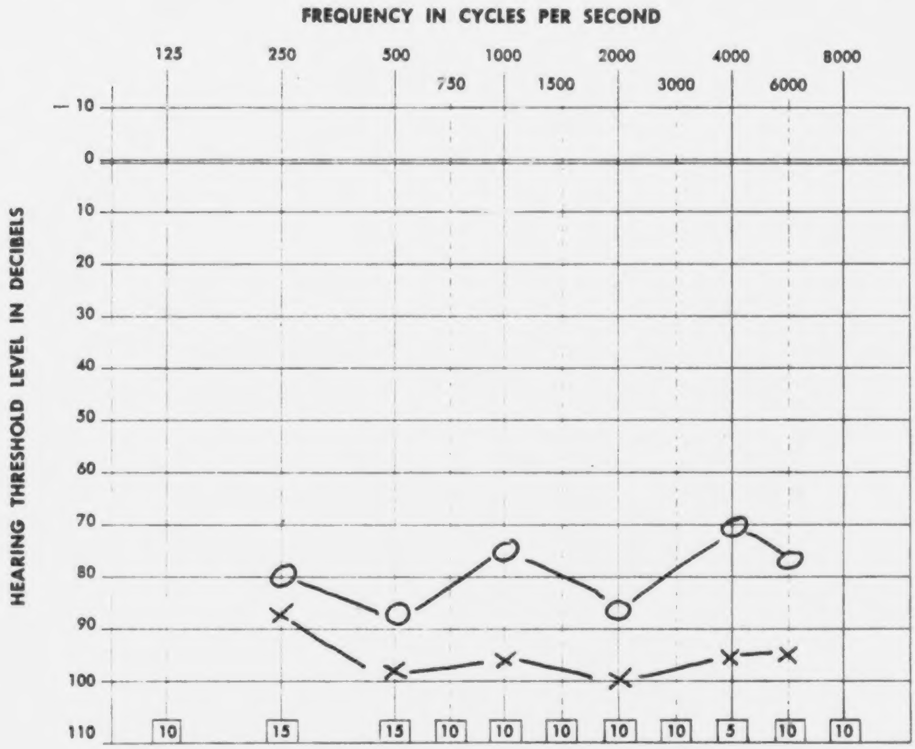
APPENDIX C-6

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name M.C.; subject 36 (w) Date of Evaluation 7-15-70

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED AND PLOTTED ON BASIS OF
ISO 1964 ☒ ASA 1951 ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt 81 dB Lt 96 dB

2F AIR: Rt 80 dB Lt 95 dB

125+250 RT dB LT dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt ______ dB Lt ______ dB

FIELD: ______ dB

(ALL LEVELS RE NORMAL SRT)

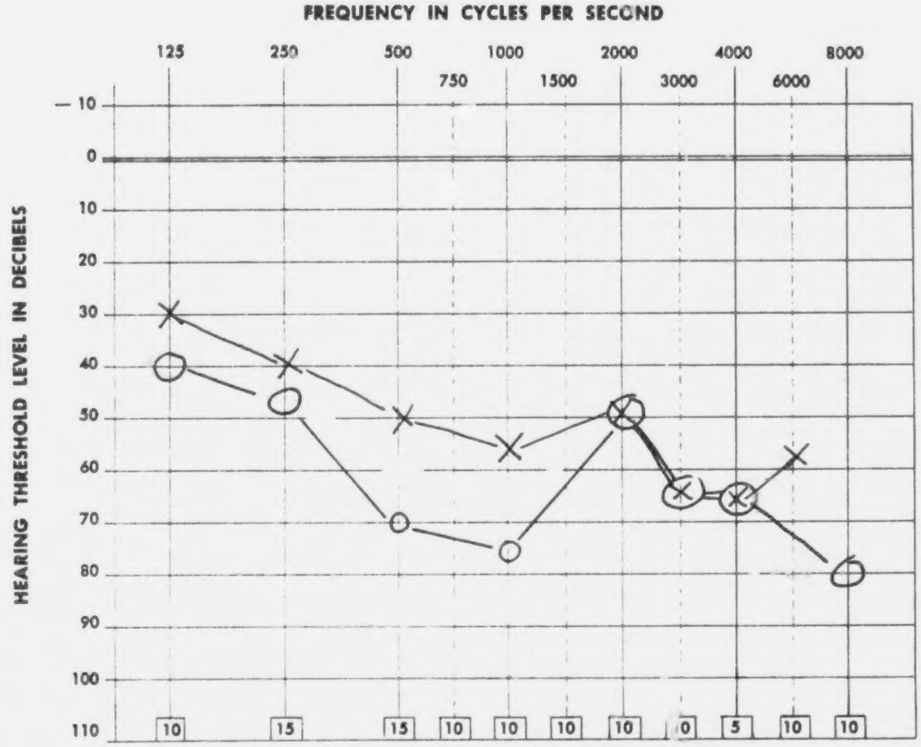
APPENDIX C-7

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name A.O.; subject 37 (w) Date of Evaluation 7-22-70

Audiogram



To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes ↑ To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED AND PLOTTED ON BASIS OF
ISO 1964 ☐ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)
3F AIR: Rt 65 dB Lt 51 dB
2F AIR Rt 60 dB Lt 50 dB
125+250 RT: 42 dB LT 35 dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER
Rt______dB Lt______dB
FIELD:______dB
(ALL LEVELS RE NORMAL SRT)

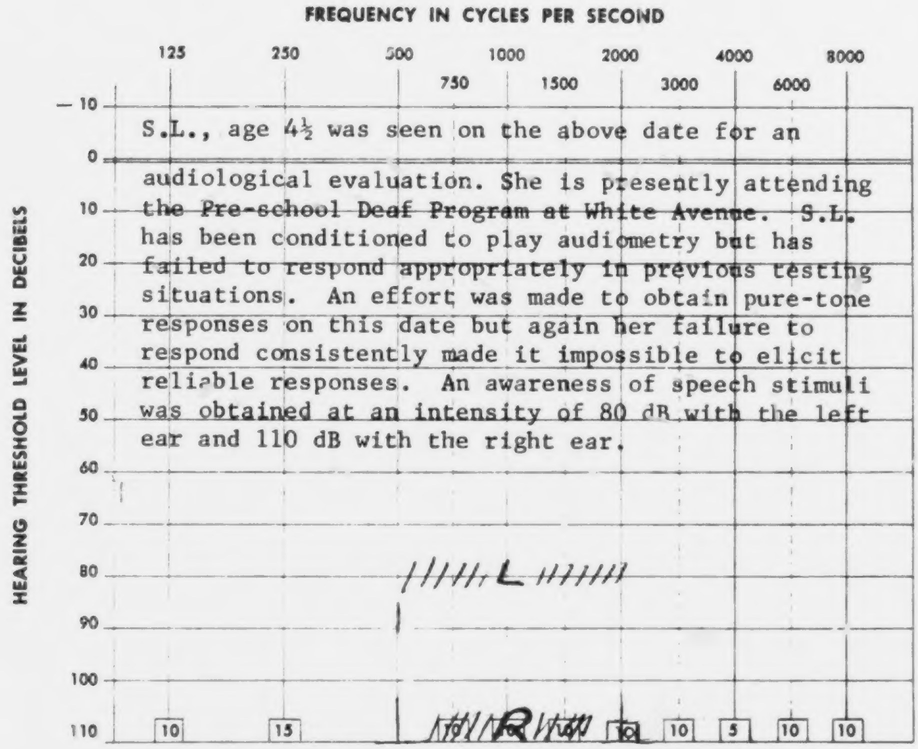
APPENDIX C-8

THE UNIVERSITY OF TENNESSEE HEARING AND SPEECH
Stadium Drive at Yale Avenue
Knoxville, Tennessee 37916

Report of Audiologic Evaluation

Name S. L.; subject 38 (w) Date of Evaluation 5-19-70

Audiogram



S.L., age 4½ was seen on the above date for an audiological evaluation. She is presently attending the Pre-school Deaf Program at White Avenue. S.L. has been conditioned to play audiometry but has failed to respond appropriately in previous testing situations. An effort was made to obtain pure-tone responses on this date but again her failure to respond consistently made it impossible to elicit reliable responses. An awareness of speech stimuli was obtained at an intensity of 80 dB with the left ear and 110 dB with the right ear.

To convert ISO 1964 threshold levels to ASA 1951 levels, subtract values in boxes. To convert ASA '51 to ISO '64, add these values. (Above values to nearest 5 dB. Specific levels are 9, 15, 14, 12, 10, 10, 8.5, 8.5, 6, 9.5, and 11.5 dB.)

THIS AUDIOGRAM WAS OBTAINED AND PLOTTED ON BASIS OF
ISO 1964 ☒ **ASA 1951** ☐
CALIBRATION

AVERAGE LEVEL FOR TEST TONES

(500, 1000 & 2000 cps)

3F AIR: Rt________dB Lt________dB

2F AIR Rt________dB Lt________dB

125 + 250 RT______dB LT______dB

SPEECH RECEPTION AWARENESS THRESHOLDS

LIVE-VOICE SPONDEES OTHER

Rt________dB Lt________dB

FIELD:________dB

(ALL LEVELS RE NORMAL SRT)